U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-280 547

Characterization of Reusable Municipal Wastewater Effluents and Concentration of Organic Constituents

Gulf South Research Inst, New Orleans, La

Prepared for

Municipal Environmental Research Lab, Cincinnati, Ohio

Feb 78

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.
EPA-600/2-78-016

2.

3. RECIPIENT'S ACCESSION NO.
PB280547

4. TITLE AND SUBTITLE
Characterization of Reusable Municipal Wastewater Effluents and Concentration of Organic Constituents

5. REPORT DATE
February 1978 (Issuing Date

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
James K. Smith, A.J. Englande, Mary M. McKown and Stephen C. Lynch

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Gulf South Research Institute
P.O. Box 26500
New Orleans, Louisiana 70186

10. PROGRAM ELEMENT NO.
1BC611

11. CONTRACT/~~GRANT NO.~~
68-03-2090

12. SPONSORING AGENCY NAME AND ADDRESS
Municipal Environmental Research Laboratory--Cin.,OH
Office of Research and Development
U.S. Environmental Protection Agency
26 West St. Clair Street, Cincinnati, Ohio 45268

13. TYPE OF REPORT AND PERIOD COVERED
Final 6-74 to 3-77

14. SPONSORING AGENCY CODE
EPA/600/14

15. SUPPLEMENTARY NOTES
Project Officer: John N. English 513/684-7613

16. ABSTRACT
The main thrust of this project was to collect organic concentrates from operating Advanced Wastewater Treatment (AWT) plants for use in health effects testing. A reverse osmosis process was employed in the first stage concentration; the organics were further concentrated and recovered from the resulting brine solution via liquid/liquid extraction. The final product was supplied to EPA for identification and toxicity testing in other on-going research efforts. In addition, chemical, physical, and biological analyses of effluent from the six AWT systems were conducted to determine how the quality of the effluents from these systems compared with current drinking water regulations. In spite of the fact that the AWT systems were not designed to produce potable water, all were characterized by high quality effluents. Pilot and fully operational plants evaluated were Lake Tahoe, California; Blue Plains, District of Columbia; Pomona, California; Dallas, Texas; Escondido, California; and Orange County, California. These systems were selected primarily because of availability and because effluent quality exceeded that of secondary treatment systems. Spot samples taken over a six to nine month period indicated that the parameters found to exceed drinking water regulations in most of the treated effluents included nitrogen (ammonia and nitrate), phenol, odor, carbon chloroform extract, turbidity, and specific heavy metals.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Waste Treatment *Water Reclamation Nutrients Viruses Organic Compounds Concentrating Potable Water	Chemical Composition Microorganisms	Heavy Metals Advanced Wastewater Treatment Reuse	13B

18. DISTRIBUTION STATEMENT
RELEASE TO PUBLIC

19. SECURITY CLASS *(This Report)*
UNCLASSIFIED

20. SECURITY CLASS *(This page)*
UNCLASSIFIED

21. NO. OF PAGES
143

22. PRICE
A07-A01

EPA Form 2220-1 (9-73)

PB 280 547

EPA-600/2-78-016
February 1978

Environmental Protection Technology Series

CHARACTERIZATION OF REUSABLE MUNICIPAL WASTEWATER EFFLUENTS AND CONCENTRATION OF ORGANIC CONSTITUENTS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Municipal Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

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NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
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EPA-600/2-78-016
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FOREWORD

The Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment, and management of wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, for the preservation and treatment of public drinking water suppliers, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research; a most vital communications link between the researcher and the user community.

The use of municipal wastewater effluents to satisfy water demands is a viable means of conserving valuable resources. This report is concerned with the characterization of reusable municipal wastewater effluents from cost-effective treatment processes. Physical, chemical, and biological parameters are used to define potable water quality. A reverse osmosis concentration technique was evaluated and used to obtain quantities of organic residues in the effluents for identification and toxicity testing in other ongoing research efforts.

Francis T. Mayo
Director
Municipal Environmental Research Laboratory

ABSTRACT

The main thrust of this project was to collect organic concentrates from operating Advanced Wastewater Treatment (AWT) plants for use in health effects testing. A reverse osmosis process was employed in the first stage concentration; the organics were further concentrated and recovered from the resulting brine solution via liquid/liquid extraction. The final product was supplied to EPA for identification and toxicity testing in other on-going research efforts.

In addition, chemical, physical, and biological analyses of effluent from the six AWT systems were conducted to determine how the quality of the effluents from these systems compared with current drinking water regulations. In spite of the fact that the AWT systems were not designed to produce potable water, all were characterized by high quality effluents.

Pilot and fully operational plants evaluated were Lake Tahoe, California; Blue Plains, District of Columbia; Pomona, California; Dallas, Texas; Escondido, California; and Orange County, California. These systems were selected primarily because of availability and because effluent quality exceeded that of secondary treatment systems.

Spot samples taken over a six to nine month period indicated that the parameters found to exceed drinking water regulations in most of the treated effluents included nitrogen (ammonia and nitrate), phenol, odor, carbon chloroform extract, turbidity, and specific heavy metals.

This report was submitted in fulfillment of Contract No. 68-03-2090 by Gulf South Research Institute under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period June 25, 1974 to March 30, 1977, and work was completed as of March 1977.

CONTENTS

Foreword iii
Abstract iv
Figures vi
Tables vii
Abbreviations and Symbols x
Acknowledgement xi

1. Introduction 1
2. Method of Study 2
    - Selection of treatment systems 2
    - Characterization of effluents 3
    - Concentrating organics 5
    - Viral determinations 6
3. Description of AWT Plants 7
    - Lake Tahoe, California 7
    - Blue Plains, District of Columbia 13
    - Pomona, California 21
    - Dallas, Texas 24
    - Escondido, California 34
    - Orange County, California 36
4. Details of Analytical Program 42
    - Reverse osmosis concentration 42
    - Organic solvent extractions and evaporations 49
    - Virus concentration 54
    - Collection and shipment of effluent samples 56
    - Analytical procedures for effluent characterization 59
5. Results and Discussion 76
    - Chemical analysis 76
    - Effluent quality and drinking water standards compliance 92

References 110
Appendix A 111

FIGURES

Number Page

1 Analytical, organics, and viral sampling schedule for AWT plants....... 4

2 Simplified schematic - South Lake Tahoe Public Utility District water reclamation plant.. 9

3 System 1 schematic, Blue Plains..15

4 System 2 schematic, Blue Plains..19

5 Flow diagram, Pomona pilot plant...23

6 Process configuration--September 1974, Dallas...........................30

7 Process flow sequence, Escondido, California.............................35

8 Wastewater reclamation process flow diagram - Orange County............37

9 Theoretical model of reverse osmosis operation...........................43

10 Basic reverse osmosis concentrator used by GSRI.........................44

11 Reverse osmosis concentrator used by NISR...............................46

12 Assembly for extraction of organics from water concentrate.............52

13 Sample laboratory analysis flow sheet....................................55

14 Ammonia quality control chart..83

15 Chlorine quality control chart...84

16 COD quality control chart..85

17 Phenol quality control chart...86

18 Sulfate quality control chart..87

TABLES

Number Page

1 Performance Characteristics - Lake Tahoe, California 8

2 Lake Tahoe Renovation Plant Effluent Quality 12

3 Effluent Quality Requirements-South Lake Tahoe 11

4 Raw Wastewater Characterization - Blue Plains 14

5 Removal Efficiencies for System 1 Operation - Blue Plains 17

6 System 2 Blue Plains, May - September 1975 20

7 Collection of Composite Samples 22

8 Pomona Raw Waste Characterization 22

9 Summary of Water Quality Characteristics through Treatment Systems 1 and 2 - Pomona (September 1 - November 30, 1975) 25

10 Summary of Water Quality Characteristics through Treatment System 3 - Pomona (September 1 - November 30, 1975) 26

11 Summary of Water Quality Characteristics through Treatment Systems 1 and 2 - Pomona (December 1, 1975 - April 30, 1976) 27

12 Summary of Water Quality Characteristics through Treatment System 3 - Pomona (December 1, 1975 - April 30, 1976) 28

13 Raw Wastewater Influent Characterization 29

14 Process Control Parameters 31

15 Hydraulic Process Control 31

16 Metals Removal Summary - Dallas 32

17 Performance Summary - Dallas 33

18 Escondido Raw Wastewater Characteristics 34

TABLES (continued)

Number Page

19 Orange County Raw Waste Characteristics.......................... 36

20 Performance Characteristics - Orange County Water Factory 21......... 39

21 Heavy Metal Removal - Orange County Water Factory 21................ 40

22 Regulatory Agency Requirements for Injection Water.................. 41

23 Organic Concentrate Sample Collection Dates......................... 45

24 Initial Extraction Procedure for RO Concentrates.................... 50

25 Modified Extraction Procedure for RO Concentration.................. 51

26 Final Extraction Procedure for RO Concentrates...................... 53

27 Procedures Used in Preparation of Organic Concentrates.............. 54

28 Experimental Results for Viral Sampling............................. 57

29 Analytical Parameters Used to Characterize Effluent Samples.......... 60

30 Preservation Methods Recommended for Selected Parameters............. 61

31 Minimum Detectable Limits for Analytical Parameters................. 62

32 Instrumental Parameters for AAS/AES Determinations.................. 69

33 Varian Instrument Settings.. 75

34 Summary of Averages for Selected Inorganic Parameters According to Treatment System.. 78

35 Summary of Averages for Organic Parameters According to AWT Plant 78

36 Summary of Averages of Physical Parameters According to AWT Plant.... 79

37 Summary of Bacteriological Parameters According to AWT Plant......... 79

38 Summary of Average for Trace Metals According to AWT Plant........... 80

39 Summary of Average for Nitrogen Parameter According to AWT Plant..... 80

40 Analysis of Demand Standard Reference Samples....................... 81

41 Data for In-House COD Standard...................................... 81

TABLES (continued)

Number		Page
42	Comparison of Values Obtained by GSRI for EPA Reference Standards	88
43	Comparison of Values Obtained by GSRI for EPA Trace Metal Reference Standards	89
44	Data for Within-Run Precision for Selected Parameters	90
45	Data for Run-to-Run Precision for Selected Parameters	90
46	Data for Run-to-Run Precision for Trace Metal Analysis	91
47	Drinking Water Standards	93
48	Results of AWT Plant Performance vs. Compliance to Drinking Water Standards (Lake Tahoe)	95
49	Results of AWT Plant Performance vs. Compliance to Drinking Water Standards (Blue Plains)	97
50	Results of AWT Plant Performance vs. Compliance to Drinking Water Standards (Orange County)	99
51	Results of AWT Plant Performance vs. Compliance to Drinking Water Standards (Pomona)	101
52	Results of AWT Plant Performance vs. Compliance to Drinking Water Standards (Dallas and Escondido)	105
53	Parameters Exceeding Drinking Water Standards	107

LIST OF ABBREVIATIONS

AAS -- atomic absorption spectroscopy
AES -- atomic emission spectroscopy
BGM -- Buffalo green monkey
BOD -- biochemical oxygen demand
CA -- cellulose acetate
CAE -- carbon alcohol extraction
CAM -- carbon absorption method
CCE -- carbon chloroform extraction
COD -- chemical oxygen demand
EPA -- Environmental Protection Agency
GC -- gas chromatograph
gpm -- gallons per minute
GSRI -- Gulf South Research Institute
JTU -- Jackson turbidity units
Lahontan R.W.Q.C.B. -- Regional Water Quality Control Board
MBAS -- methylene blue active substance
mgd -- million gallons per day
MLSS -- mixed liquor suspended solids
MLVSS -- mixed liquor volatile suspended solids
MPN -- most probable number
NISR -- National Institute of Scientific Research
NTU -- nephelometric turbidity units
PFU -- plaque-forming units
PMK -- primary monkey kidney
RO -- reverse osmosis
SRT -- sludge residence time
TDS -- total dissolved solids
TH -- total hardness
TKN -- total Kjeldahl nitrogen
TOC -- total organic carbon
TON -- threshold odor number
TPO_4 -- total phosphate
TSS -- total suspended solids

ACKNOWLEDGMENTS

We wish to acknowledge the advice and suggestions of EPA project coordinators Mr. J. English and Dr. F. Kopfler and the cooperation of the individual AWT plant management and personnel. The concentrations, collections, and analyses by employees of Gulf South Research Institute in both New Orleans and New Iberia, Louisiana, are also appreciated. Finally, none of this work would have been possible without the financial support of the Environmental Protection Agency.

SECTION 1

INTRODUCTION

The indirect, unplanned reuse of wastewater for domestic purposes is widespread. Wastewater at times represents a significant portion of the total flow in many receiving waters. Since the typical wastewater treatment plant does not remove all the contaminants from wastewater, there is a concern about the health risk to users of these water supplies. A knowledge of the appropriate levels of treatment is necessary to ensure the safety of water supply intakes in the vicinity of discharges. As a first step in understanding the significance of this problem, there is a need to know the types and quantities of potentially hazardous substances in effluents produced by what is currently the most effective wastewater treatment technology.

The objectives of this project were twofold: (1) to characterize effluents from both pilot and full scale municipal wastewater treatment systems employing cost-effective processes with respect to physical, chemical, and biological parameters used to define potable water quality, and (2) to obtain samples of organic concentrates from the effluent for identification and use in other EPA health effects testing programs, and to evaluate the concentration technique used.

SECTION 2

METHOD OF STUDY

SELECTION OF TREATMENT SYSTEMS

The treatment systems selected for study employ a wide range of biological and physical-chemical processes that are typical of the best available technology. Each system was part of an independent, full-scale or pilot scale project with specific, individual goals. In general, all of the treatment systems were in stable operation with the exception of the Orange County plant, which was in an initial start-up period when samples were taken for this project. Effluent characterization and concentration of organics were undertaken at the following six locations:

South Lake Tahoe, California

A 0.33 m^3/s (7.5 mgd) plant processing wastewater treated by primary clarification, activated sludge and clarification, high lime coagulation and clarification, partial ammonia stripping, recarbonation and settling, filtration, activated carbon, and chlorination (raw sewage is predominantly of domestic origin).

District of Columbia (Blue Plains)

Two pilot systems processing raw wastewater were investigated. System 1 operated at 3.15 l/s (50 gpm) and employed screening, low-lime clarification, breakpoint chlorination, granular activated carbon, and dual media filtration. System 2 operated at 2.21 l/s (35 gpm) and employed screening, low-lime clarification, nitrification, denitrification, granular activated carbon, dual media filtration, and chlorination.

Pomona, California

Three pilot systems processing 6.31 l/s (100 gpm) were investigated. Each involved processing of wastewater treated by primary sedimentation, activated sludge and clarification, and granular activated carbon. The remaining treatment processes involved:

System 1 - chlorination
System 2 - chlorination followed by activated carbon
System 3 - ozonation followed by activated carbon

Dallas, Texas

A 6.31 l/s (100 gpm) pilot plant processing wastewater treated by primary sedimentation, trickling filtration, secondary sedimentation, nitrifying activated sludge and clarification, high lime coagulation and clarification, recarbonation, filtration, carbon adsorption, and chlorination.

Escondido, California

A 13.12 l/s (208 gpm) plant processing water by contact stabilization with approximately 60% of the polished water further treated by mixed media filtration followed by reverse osmosis.

Orange County, California

A 0.657 m^3/s (15 mgd) plant processing wastewater treated by primary clarification, trickling filtration and clarification, high lime coagulation and clarification, ammonia stripping, recarbonation and settling, filtration, activated carbon, and chlorination (raw sewage contains refinery and metal plating wastes).

CHARACTERIZATION OF EFFLUENTS

Samples were obtained from on site personnel operating the designated wastewater treatment systems at each of these locations according to the schedule shown in Figure 1. The samples were representative of the 24-hr period for the sampling day shown. Before initiating the sampling programs, a senior analytical chemist from GSRI visited each site to coordinate sampling, splitting of samples, and shipping. It was emphasized that all participants should follow procedures, incorporating necessary preservation methods and maintaining sample reliability; all shipments to GSRI were to be made under specified conditions in an expeditious manner. Labeled containers containing the required preservatives were shipped from GSRI to each site so that the composite sample could be split and preserved prior to shipment to GSRI. Detailed written procedures were forwarded to the sites prior to the initiation of sampling. Routine telephone liason was established to ascertain the status of each process operation prior to the collection of samples. This action ensured that samples were not taken during an unusual breakdown in system operation. The time and date of the collection of all samples are included in the records of the program.

The parameters used to characterize the effluents, the analytical determinations, and all special shipping, storage, or handling requirements are discussed in detail in Section 4. However, in all cases, standard analytical methods as defined in the latest "Standard Methods (1) or EPA method publications (2) were employed. Accuracy of the results was assured by following the procedures outlined by the EPA quality control manual (3).

In addition to performing sample analysis, GSRI solicited other process operating data available from site records, routine operating procedures, and other reports from the plants to state or local agencies. The data requested included a description of the process with flow diagrams, daily

	SAMPLING SCHEDULE 1974					SAMPLING SCHEDULE 1975											SAMPLING SCHEDULE 1976		
	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	JANUARY	FEBRUARY	MARCH
DALLAS		ANALYTICAL* 5,13 VIRUS 15	ANALYTICAL 4,16,21 ORGANIC** 3-5		ANALYTICAL 13 ORGANIC 10-12 VIRUS 10, 11	ANALYTICAL 24,29													
POMONA 1		ANALYTICAL 20 ORGANIC 25	ANALYTICAL 2,7,21	ANALYTICAL 11 VIRUS 11,12	ANALYTICAL 6				ANALYTICAL 24					ANALYTICAL 16		ANALYTICAL 7 VIRUS 6			
POMONA 2		ANALYTICAL 25,27	ANALYTICAL 9,23 ORGANIC 2	ANALYTICAL 13 VIRUS 11,12	ANALYTICAL 6									ANALYTICAL 12,19,24		VIRUS 5,7			
POMONA 3											ORGANIC 17			ANALYTICAL 23,25	ANALYTICAL 24	ANALYTICAL 4,6 VIRUS 4,6		ANALYTICAL 11,18	ANALYTICAL 4,16
ORANGE COUNTY																	ORGANIC 27	ANALYTICAL 11,13,18,20 ORGANIC 3	ANALYTICAL 3, 10,12
TAHOE	VIRUS 16	ANALYTICAL 27 ORGANIC 5	ANALYTICAL 9,23 ORGANIC 24	ANALYTICAL 7,21 VIRUS 16	ANALYTICAL 7	ANALYTICAL 10	ANALYTICAL 6,21	ANALYTICAL 12	ANALYTICAL 8		ANALYTICAL 10	ANALYTICAL 2							
BLUE PLAINS		ANALYTICAL 12,20,27 ORGANIC 19-21 VIRUS 11							VIRUS 15,16	ORGANIC 12,30 VIRUS 30	ANALYTICAL 13 ORGANIC 1	ANALYTICAL 9	ANALYTICAL 14,24	ANALYTICAL 17,23 VIRUS 9					
ESCONDIDO												ANALYTICAL 7 ORGANIC 8 VIRUS 8							

*Analytical samples represent a 24-hr composite unless otherwise indicated in report.
**Organic samples were collected as grab samples over a 48-hr period on the days indicated.

Figure 1. Analytical, organic, and viral sampling schedule for AWT plants.

flow measurements, and size and characteristics of the community serviced by the treatment plant.

CONCENTRATING ORGANICS

Almost all types of wastes contribute to the dissolved organic chemical content of water supply sources. Improvements in techniques used to identify such organic compounds in trace quantities in water sources have increased awareness of potential hazards created by their presence.

In order to evaluate fully their effects on human health, dissolved organic compounds must be isolated, identified, and measured. First, it is necessary to concentrate the organic chemicals, since concentrations in most drinking waters are too dilute to be studied with present toxicological techniques. This concentration step must be performed without alteration or destruction of the chemical species and with techniques that yield at least a representative fraction of the solutes present. Ideally, the concentration method should yield a quantitative recovery of the solutes.

This part of the project was designed to collect organics for future identification and testing in other EPA sponsored efforts, and to evaluate and improve concentrating techniques to develop the most practical membrane for reverse osmosis concentration of organic contaminants.

Evaluating Membrane Techniques

To evaluate the efficiency of membrane techniques in concentrating trace organic solutes in water supplies, Gulf South Research Institute (GSRI), in collaboration with the EPA Environmental Research Center, Cincinnati, Ohio, developed an analytically sound separation scheme, based on the differing responses of membrane materials to various solute classes (4).

The concentration scheme was designed to treat both volatile and nonvolatile organics, without causing structural or chemical alterations. The mechanics of concentration were designed to provide concentration factors adequate for subsequent analysis with reasonable laboratory time expenditures.

The applicability of concentration schemes to real situations was investigated by measuring the interactions between selected membranes and representative solutes. A membrane was devised which could concentrate a wide range of unidentified organic solutes in water samples for analytical separation and identification.

Field Testing of the Membrane

A series of field tests was conducted to evaluate the membrane concentration processes, and to provide data on selected wastewater treatment systems. During the project period, 12 samples from the 6 sites previously described were collected and concentrated. The concentrates from these streams were shipped to the EPA in Cincinnati, Ohio, for analytical and toxicological evaluations.

Sampling was performed during stable operational periods at each site. Plant operators provided operational data for correlation with the quality and quantity of dissolved organics found in the samples.

All sampling and shipments were conducted by representatives of either the West Coast subcontractor, National Institute of Scientific Research (NISR) or GSRI, who performed the concentrations and documented that the samples were taken at a time of routine operation.

Organics in the plant effluents were initially concentrated on site by reverse osmosis. Samples from plants on the West Coast (Pomona, Lake Tahoe, Escondido, and Orange County) were transported to the NISR in Los Angeles to be processed since this was more efficient than sending GSRI personnel and equipment from New Orleans. The reverse osmosis concentration of samples from Dallas and Washington, D.C., was performed at the pilot plants by GSRI personnel. Standard techniques were used in these concentrations. The sample volumes were reduced 40 to 50 fold, and extracted with two carefully chosen, pure organic solvents under three conditions. The procedures used in securing samples are detailed in Section 4.

Improving Concentrating Techniques

Improvements in the performance and predictability of membrane separation techniques were needed to support the field effort and to extend present technology. Investigations were conducted to support the field trials. Further, efforts were made to improve the utility of the membrane methods and to extend the scope of membrane applications.

VIRAL DETERMINATIONS

The objective of the virus sampling program was primarily to screen for the presence or absence of the more prevalent virus groups. If positive results were obtained, specific identifications were made for Polio 1-3; Echo 1-7, 9, 11-27, 29-33; Coxsachie A 7, 9, and 16, and Coxsachie B 1-6. All samples were taken and prepared for shipment by Carborundum Company personnel using the Aquella® virus monitoring apparatus. This apparatus processes 378.5 liters of water in approximately two hours; the product is a 10-ml sample containing any virus present in the 378.5 liters. The neutralized virus concentrate was stabilized, frozen, and shipped by air to the laboratory for analysis.

SECTION 3

DESCRIPTION OF AWT PLANTS

LAKE TAHOE, CALIFORNIA

General Description

This advanced wastewater treatment plant has a capacity of 0.328 m^3/s and incorporates the unit operations of primary clarification, activated sludge and sedimentation, high lime coagulation and clarification, ammonia stripping, recarbonation, filtration, carbon adsorption, and chlorination.

Samples of system effluent for characterization studies were composited from 0900 of the day indicated to 0900 of the following day by on-site personnel. Samples were mailed to GSRI, where analyses were conducted. Samples were composited (except where indicated) on the following days: September 26, October 8 and 21, November 21 (grab), and December 7, 1974 (grab); January 16 (grab), February 5 and 20, March 11, April 7, June 17, and July 1, 1975, for general analysis; and on September 9 and October 24, 1974, for concentration of organics using the reverse osmosis technique. Samples for virus analysis were taken on August 16 and November 16, 1974.

Influent Characteristics

The raw sewage entering primary treatment is mainly domestic and relatively low in strength (5). Typical raw wastewater characteristics and final AWT plant effluent quality observed over the study period are presented in Table 1.

Treatment Sequence

Figure 2 illustrates the flow and process configuration during the sampling period. Table 1 lists typical influent and effluent characteristics for average design flow of 0.328 m^3/s.

Primary treatment for the removal of suspended solids and secondary treatment with conventional activated sludge processes are used to reduce the load of solid organic components of the wastewater. Excess activated sludge is wasted to the primary clarifier.

To achieve good ammonia removals through the ammonia stripping tower, the activated sludge system is operated in such a way as to prevent nitrification. The food to microorganism ratio is maintained above 0.35, the mixed liquor suspended solids at 2000 mg/l, and the sludge age at 4-6 days. The

TABLE 1. PERFORMANCE CHARACTERISTICS - LAKE TAHOE, CALIFORNIA

Parameter	Raw Sewage (Typical) Avg.	Raw Sewage (Typical) Med.	Raw Sewage (Typical) Range	AWT Effluent (over study period) Avg.	AWT Effluent (over study period) Med.	AWT Effluent (over study period) Range
Average daily flow (m^3/sec)				0.144	0.149	0.122-0.175
BOD_5 (mg/1)	134	130	79-229	1.5	1.6	0.7-2.0
COD (mg/1)				16	15	6-21
Suspended Solids (mg/1)	232	204	24-608	--	--	--
MBAS (mg/1)	6.1	6.0	3.1-7.8	0.01	0.006	0.001-0.04
Turbidity (JTU)	--	--	--	0.8	0.6	0.4-2.0
pH	--	--	--	--	--	6.3-8.0
Chlorine Residual (mg/1)	--	--	--	2.8	2.0	1.7-5.6
Coliform (MPN/100 ml)	--	--	--	<2	<2	--
Ammonia N (mg/1)	21.0	20.6	13-30	18.5	18.6	6.9-29.8
Nitrate N (mg/1)	0.34	0.28	0-2.1	2.1	1.2	0.6-7.4
Nitrite N (mg/1)	0.08	0.08	0.02-0.23	0.4	0.1	0.1-1.7
Phosphorus P (mg/1)	10.7	10.6	3.6-20.4	0.6	0.7	0.2-0.9
Alkalinity (mg/1 as $CaCO_3$)	199	193	114-285	209	215	86-309
Hardness (mg/1 as $CaCO_3$)	106	106	60-146	169	167	108-232
TDS (mg/1)				366	356	234-487
Chloride (mg/1)				68	49	23-137
Sulfate (mg/1)				27	27	21-30

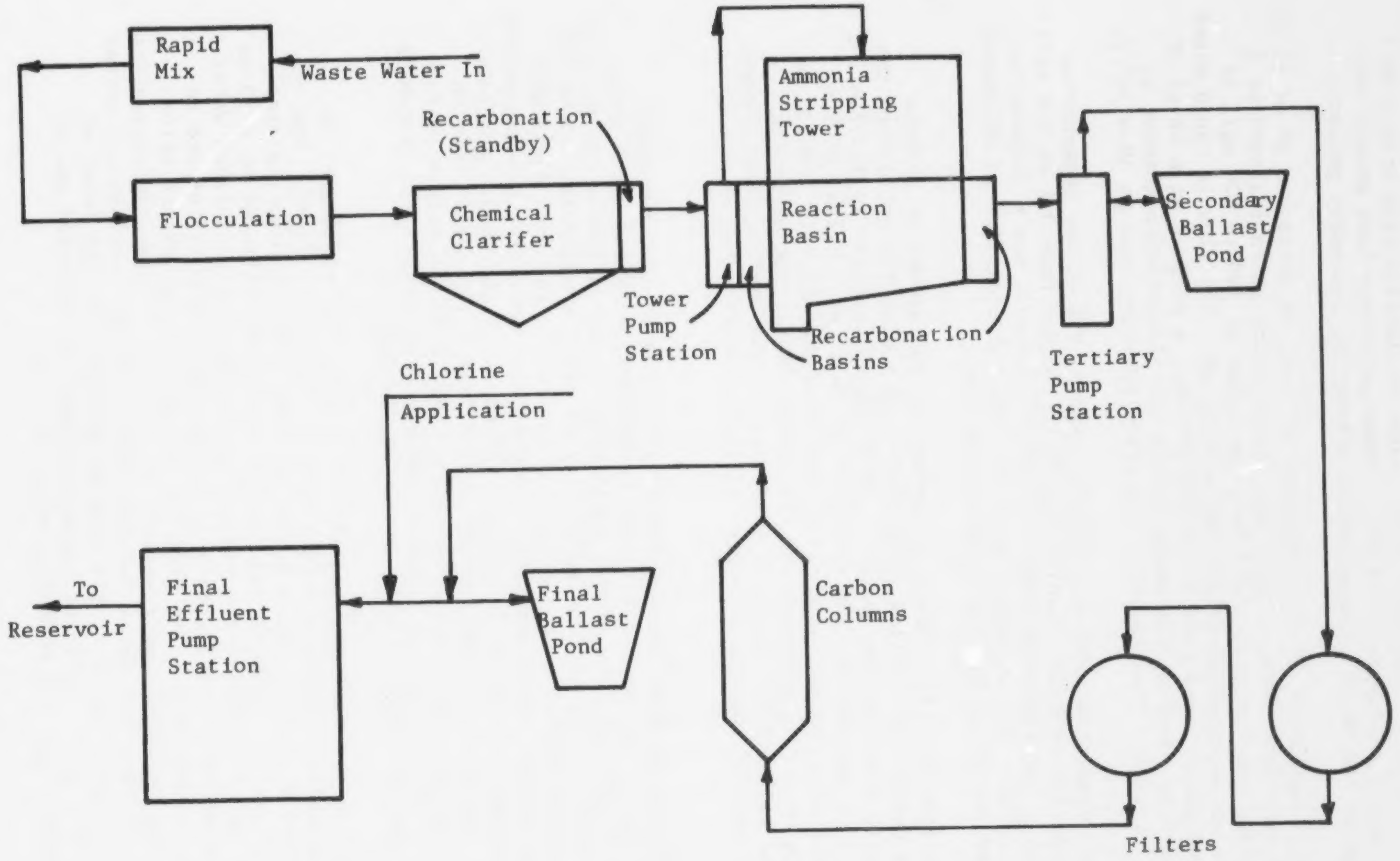

Rapid Mix
Waste Water In
Flocculation
Recarbonation (Standby)
Chemical Clarifer
Ammonia Stripping Tower
Reaction Basin
Tower Pump Station
Recarbonation Basins
Secondary Ballast Pond
Tertiary Pump Station
Chlorine Application
To Reservoir
Final Effluent Pump Station
Final Ballast Pond
Carbon Columns
Filters

Figure 2. Simplified schematic - South Lake Tahoe Public Utility District water reclamation plant.

mixed liquor is also periodically dosed prior to clarification with 2 mg/l chlorine to retard nitrifying bacteria. These practices have caused very little change in the NH_3-N concentration across the secondary process.

Chemical coagulation of the secondary effluent to achieve a pH of 11 is accomplished with lime using a rapid mix flocculation basin followed by a 30.48-m diameter conventional clarifier. A dosage of 300 to 400 mg/l of calcium oxide is required to attain the desired pH. The flow is rapid mixed for 30 sec and flocculated over a 4.5 min period. A polymer at a level of 0.1 to 0.3 mg/l is added as the water leaves the flocculation chamber to improve clarification. The chemical clarifier overflow rate is 39 $m^3/m^2/d$.

The lime coagulation system typically removes 95% of the phosphorous received. Overflow from the clarifier normally ranges from 0.2 to 0.6 mg/l phosphate with a corresponding turbidity level between 1 and 6 Jackson Turbidity Units (JTU). The underflow from the chemical clarifier is thickened and recalcined for reuse in a multihearth furnace.

Nitrogen from the lime clarified wastewater is removed by ammonia stripping. A cross-flow cooling tower with 7.32 m diameter fan strips the volatile ammonia from the wastewater. The designed capacity is 11.32 m^3 of air per gallon of wastewater. The fill area is 36 m^2 at a height of 8 m. Removal efficiencies across the cooling tower for ammonia vary from 30 to 90%, depending on air temperature and the extent of calcium carbonate buildup in the fill before cleaning. Influent to the cooling tower ranges from 15 to 30 mg/l of ammonia nitrogen; effluent values range from 2 to 15 mg/l.

After ammonia removal, the wastewater is processed in a two-stage recarbonation unit. In the first stage, compressed, scrubbed stack gases from the lime recalcining and sludge incineration systems reduce the pH from 11.0 to 9.3, which is the minimum solubility of calcium carbonate. Some 20% additional calcium carbonate can be settled out in the reaction basin with the dual stage system. This additional removal also decreases the deposition of calcium carbonate in the ballast ponds and on the filter media and activated carbon. The second stage reduces the pH from 9.3 to near 7.0 with scrubbed stack gases. Total basin detention time is 30 min with a surface overflow rate of 98 $m^3/m^2/d$. A standby carbon dioxide compressor system is available in case of failure in the recalcination furnace.

Subsequent to the secondary recarbonation step, the wastewater is pumped to mixed media filters at a flux rate of about 3.4 $l/s/m^2$. The patented (Neptune Microfloc, Inc.) coarse-to-fine filter medium contains coal, sand, and garnet. Alum is injected in the filter influent at a 10 to 30 mg/l dosage level to obtain the desired turbidity in the finished water. Polyelectrolyte or secondary flocculants may be added as a filter aid to control solids breakthrough. Two beds are operated in series and three pairs of beds are operated simultaneously in parallel. Automatic backwashes at a 10.18 $l/s/m^2$ flux rate occur automatically. Phosphorous removal across the filterbeds ranges from 50 to 99% with an average effluent level of phosphorous at 0.1 mg/l. Effluent concentrations for suspended solids average less than 1 mg/l and turbidity about 0.5 JTU.

A carbon adsorption treatment follows filtration. The activated carbon system includes 8 steel columns, each containing 19.958 metric tons (19,958 kg) of 8 x 30 mesh granulated activated carbon. Each column employs 50 m^3 of carbon at an effective depth of 4.2 m. A parallel feed, upflow scheme is used at a hydraulic loading of 4.4 $l/s/m^2$ and a 17-min contact time. Chemical oxygen demand (COD) concentrations in the separation bed effluent average 20 mg/l with approximately 50% removal across the activated carbon. Biochemical oxygen demand (BOD) concentrations in the separation bed effluent range from 3 to 6 mg/l. Color removals across the unit average 50 to 70%. A corresponding range of 12 to 15 units in the influent and 4 to 7 units in the effluent is obtained.

The carbon is regenerated after an approximate dosage of 29.96 g carbon per cubic meter treated by the pilot unit columns. A batch of 2700 kg of carbon is withdrawn in sequence from each column for regeneration.

A multihearth furnace operating at near 900°C regenerates the spent carbon. Furnace feed rates can be varied from 45.4 to 2721.6 kg per day. A loss of 5 to 8% carbon is observed during regeneration due to attrition and batch operation.

Final chlorine disinfection is used before discharge from the plant. Since the chlorine demand of the final effluent is very low, instantaneous chlorine values of 2 to 3 mg/l ensure complete disinfection.

A summary of effluent quality during the study period as obtained from plant records is presented in Table 2.

Effluent Quality Goals

The Lake Tahoe advanced wastewater treatment plant is designed to produce an effluent suitable for export and use in a recreational lake, Indian Creek Reservoir. Effluent quality requirements are given in Table 3.

TABLE 3. EFFLUENT QUALITY REQUIREMENTS
SOUTH LAKE TAHOE WATER RECLAMATION PLANT

	Requirements			
		Lahontan R.W.Q.C.B. Percent of Time		
Description	Alpine Co.	50	80	100
MBAS, mg/l, less than	0.5	0.3	0.5	1.0
BOD, mg/l, less than	5	3	5	10
COD, mg/l, less than	30	20	25	50
Suspended Solids, mg/l, less than	2	1	2	4
Turbidity, JTU	5	3	5	10
Phosphorus, mg/l, less than	NO REQUIREMENTS			
pH, units	6.5 to 8.5	6.5 to 9.0		
Coliform, MPN/100 ml	Adequately Disinfected	Median less than 2 Max. No. Consecutive Samples greater than 23, 2		

TABLE 2. LAKE TAHOE RENOVATION PLANT EFFLUENT QUALITY
(September, 1974 - July, 1975)

MONTH	9/74	10/74	11/74	12/74	1/75	2/75	3/75	4/75	5/75	6/75	7/75	AVERAGE
Average daily flow, m/s (mgd)	0.14 (3.3)	0.13 (2.9)	0.12 (2.8)	0.13 (3.0)	0.14 (3.1)	0.15 (3.4)	0.15 (3.5)	0.16 (3.6)	0.16 (3.6)	0.16 (3.6)	0.18 (4.0)	0.14 (3.3)
BOD_5 (mg/l)	2.0	1.9	1.7	1.7	2.0	1.5	1.0	1.0	0.7	1.2	1.7	1.5
COD (mg/l)	15	6	11	21	20	12	20	20	18	14	14	16
Suspended Solids (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0
MBAS (mg/l)	0.04	0.01	Trace	0.01	0.03	0.001	0.003	0.008	0.002	0.005	0.006	0.01
Turbidity (JTU)	0.4	0.6	0.6	0.5	0.8	0.9	0.8	0.6	0.4	1.6	2.0	0.8
pH	7.1-8.0	6.9-7.6	7.1-8.0	6.8-7.9	7.4-8.0	6.8-7.8	6.5-7.3	6.5-7.5	6.6-7.7	6.3-7.8	7.3	6.3-8.0
Chlorine Residual (mg/l)	1.8	1.7	1.7	2.2	1.7	2.3	5.6	4.3	4.4	2.6	2.5	2.8
Coliform (MPN/100 ml)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Ammonia N (mg/l)	29.8	24.8	24.4	26.2	24.5	18.6	13.0	12.1	12.2	10.8	6.9	18.5
Nitrate N (mg/l)	7.4	4.9	0.9	1.8	1.1	1.2	1.7	0.6	1.2	1.4	0.9	2.1
Nitrite N (mg/l)	1.7	1.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.1	0.4
Phosphorus P (mg/l)	0.5	0.2	0.3	0.9	0.7	0.7	0.6	0.8	0.8	0.7	0.3	0.6
Alkalinity (mg/l as $CaCO_3$)	237	215	258	309	283	246	177	148	162	181	86	209
Hardness (mg/l as $CaCO_3$)	-	116	140	140	108	167	168	232	230	-	223	169
TDS (mg/l)	295	234	301	356	376	350	487	454	446	445	286	366
Chloride (mg/l)	41	35	23	40	49	41	103	96	91	94	137	68
Sulfate (mg/l)	25	30	28	24	30	28	27	29	24	27	21	27

BLUE PLAINS

General Description

Two pilot wastewater treatment systems were sampled at this location. During September 1974, System 1, which employed physical-chemical processes, was sampled. During June through September 1975, System 2, which employed both biological and physical-chemical processes, was sampled.

The 2.2 l/s AWT pilot plant of System 1 incorporated unit operations of low lime clarification, breakpoint chlorination or neutralization, activated carbon adsorption, and dual media filtration. The System 2 flow sequence of the reuse pilot plant consisted of hydro-sieving, low-lime clarification, dispersed growth nitrification, downflow columnar denitrification, carbon adsorption, mixed media filtration, and chlorination.

Composite samples (except where indicated) were collected on the following dates: September 11, 20 (grab), and 26, 1974; and June 12, July 8, August 23, and September 13, 17 (grab), and 22, 1975. Samples taken for organic concentration by reverse osmosis reflected operation from September 19 - 21, 1974, and from May 29 to June 1, 1975. Samples for virus analysis were taken on September 11, 1974; and April 15, 16, and May 30, 1975.

Influent Characteristics

Almost 100% of the raw wastewater is of municipal origin from the Washington, D.C., metropolitan area. Wastewater characteristics for the study periods of September 1974, April through May 1975, and May through September 1975, are summarized in Table 4. The weighted average of parameters indicates that this sewage can be characterized as domestic and of weak strength (5).

Treatment Sequence

System 1, September 1974 Study--

Figure 3 illustrates the process flow configuration and operating conditions for System 1 during the September 1974 sampling period.

Following screening of the raw wastewater by a Bauer Hydrasieve, 2.21 l/s waste is treated by a low lime clarification system. Powdered calcium oxide is added to the flash mix tank at an average dose of 200 mg/l as CaO, maintaining the pH at 10.5. To improve clarification, ferric chloride is added to effect a concentration of 15 mg/l as Fe^{3+}. Settled solids are reapplied to the flash mix tank at 15% of the total flow. The wastage rate from the clarifier is 2.25% of the total flow, with a concentration of 2.1%. Backwash water from the carbon adsorption and filtration systems is returned to the flash mix tank (8 min. retention) at a rate of 0.63 l/s. The hydraulic loading to the clarifier with backwash is increased from 11.88 to 15.26 $l/s/m^2$ for approximately 18 hours per day.

Effluent from the low lime clarification system is split, feeding 1.10 l/s each to Systems I and J. The parallel systems include breakpoint

TABLE 4. RAW WASTEWATER CHARACTERIZATION-BLUE PLAINS

Parameter	Sept. 1974	April - June 1975	June - Sept 1975	Average (Weighted)
pH	--	7.2	--	7.2
Alkalinity (mg/1 as $CaCO_3$)	120	119	--	120
Total Organic Carbon, TOC (mg/1)	81	74	65	70
Biochemical Oxygen Demand, BOD_5* (mg/1)	104	119	82	98
Chemical Oxygen Demand, COD (mg/1)	247	241	211	227
Phosphorus (mg/1 as PO_4)	20	16	13	15
Total Kjeldahl Nitrogen (mg/1 as N)	20	21	17	19
Ammonia Nitrogen (mg/1 as N)	17	18	16	17
Nitrate Nitrogen (mg/1 as N)	--	0.1	0.1	0.1
Total Suspended Solids, TSS (mg/1)	128	116	100	114
Total Dissolved Solids, TDS (mg/1)	--	290	--	290

*Five-day BOD

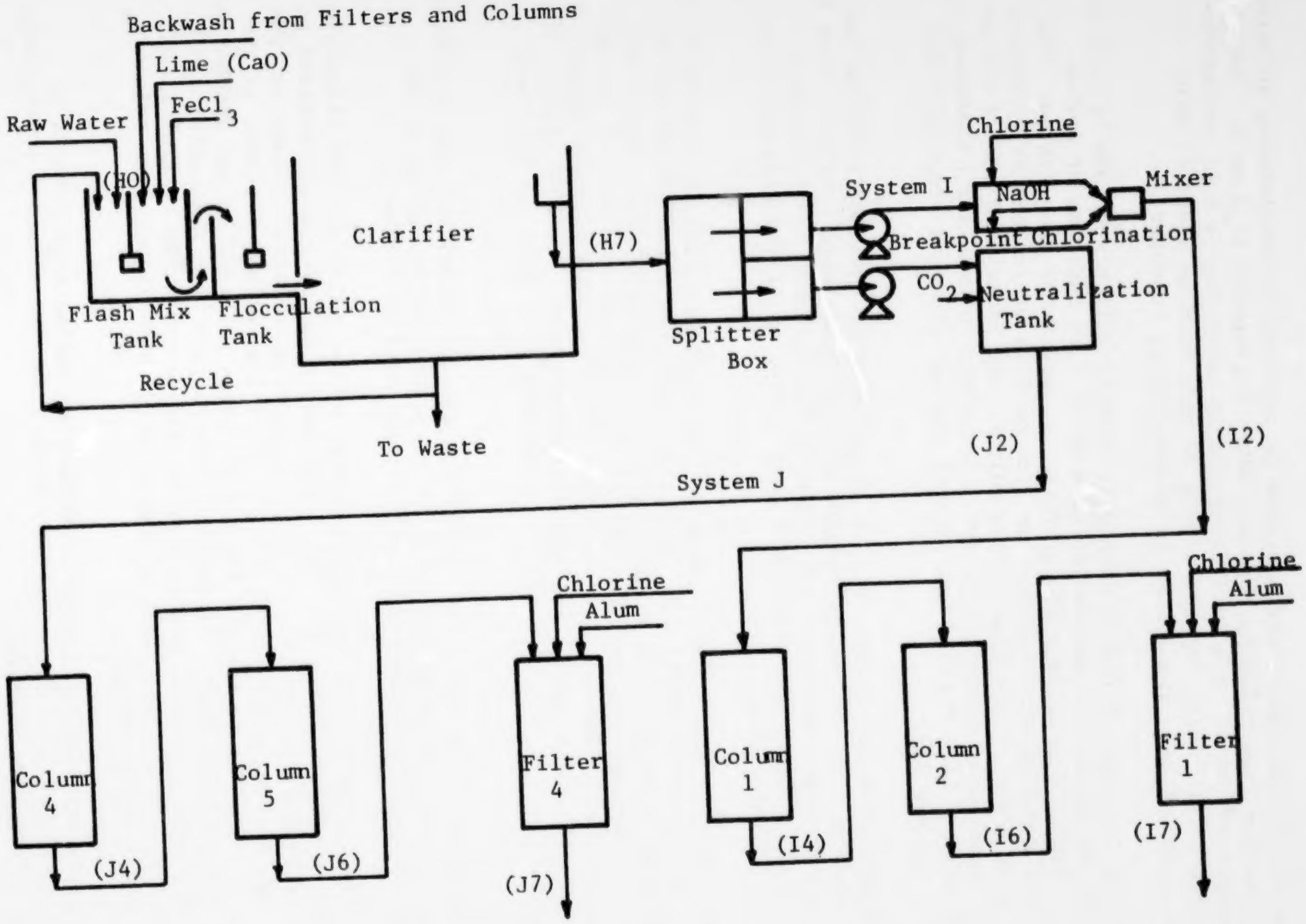

Backwash from Filters and Columns
Lime (CaO)
Raw Water
FeCl3
(HO)
Flash Mix Tank
Flocculation Tank
Clarifier
Recycle
To Waste
(H7)
Splitter Box
System I
Chlorine
NaOH
Mixer
Breakpoint Chlorination
CO2
Neutralization Tank
(J2)
(I2)
System J
Chlorine
Alum
Column 4
Column 5
Filter 4
Column 1
Column 2
Filter 1
(J4)
(J6)
(J7)
(I4)
(I6)
(I7)

Figure 3. System 1 schematic, Blue Plains.

chlorination, carbon adsorption, and dual media filtration (System I); and neutralization, carbon adsorption, and dual media filtration (System J).

The breakpoint chlorination system is operated by maintaining pH between 7 and 8 and the free chlorine residual after breakpoint at 5 mg/l. Dosage requirements are based on a 10:1 $Cl:NH_3$ ratio resulting in a Cl concentration of 100 to 120 mg/l. Approximately 70 mg/l NaOH is added to help maintain constant pH. The system is controlled by computer.

In the J system, a 1.22 m diameter, mechanically mixed tank is used to neutralize the clarified wastewater to a pH of 7 by addition of carbon dioxide. Two 1.83-m columns are operated in series for each system. The columns are downflow with a detention time of 12.5 min/column at a loading rate of 2.38 $l/s/m^2$. The lead carbon columns are backwashed once a day or if the pressure drop exceeds 2.04 atm. Secondary columns are backwashed every 48 hours. Lead filters experienced average pressure drops of 0.108 and 0.084 atm per day.

Effluent from the carbon columns is polished by dual media filtration in both systems. The hydraulic loading rate is 2.04 $l/s/m^2$/filter. Alum at 20 mg/l and chlorine at 5 mg/l are added to the influent to the filters. The dual-media filters are backwashed once a day, or if the pressure drop across the filter exceeds 0.295 atm.

Data for this pilot plant operation for September 1974 are presented in Table 5. Upsets were experienced with the breakpoint chlorination system. These included a malfunction in the computer, clogging of the caustic and chlorine feed mechanisms, and the lack of necessary maintenance of the on-stream analytical sensors. Best operation occurred during manual operation. The NH_3-N residual averaged 2.16 following breakpoint. With no upsets, NH_3-N residuals of 0.4 to 0.6 mg/l and TKN residuals of 1.2 to 1.5 mg/l are possible.

Difference in the operation of the two adsorption systems was attributed to the effect of biological activity, which is present in System J, but minimized in System I because of the basically sterile influent.

Results indicate that the System I dual media filter was not effective in removing organics (Table 5). The reduction in efficiency was related to the lack of biological activity in both the activated carbon column and the filter. The effectiveness of the filter following carbon treatment is the extent of its ability to capture biological cells produced in and discharged from the adsorption system. Breakpoint chlorination in effect eliminates bioactivity; hence, soluble organics which may be converted to biological cells and captured by the filter in the J System pass through the columns and filters of the I System.

The effluent from the I System was sampled during this project to characterize the effect of breakpoint chlorination and obtain a concentrate of highly chlorinated organics.

TABLE 5. REMOVAL EFFICIENCIES FOR SYSTEM 1 OPERATION-BLUE PLAINS

Type of Effluent	Location	TOC		BOD		COD		TPO_4		TKN		NH_3		Suspended Solids	
		mg/1	%R*	mg/1	%R	mg/1	%R	mg/1	%R	mg/1	%R	mg/1	%R	mg/1	%R
Raw	H-0	81.1	--	104	--	247	--	20.3	--	20.1	--	16.5	--	128	--
Clarified	H-7	22.3	72.5	29.3	71.1	56.6	77.1	1.42	93.0	12.7	36.8	11.7	29.1	13.8	89.2
Breakpoint	I-2	21.5	73.5	28.5	72.6	60.8	75.4	1.53	92.5	3.95	80.3	2.19	86.7	14.3	88.8
Adsorbed	I-4	13.6	83.2	16.2	84.4	34.7	86.0	0.51	97.5	3.36	83.3	2.16	86.9	1.5	98.9
Adsorbed	I-6	8.5	89.5	9.3	91.0	21.7	91.2	0.43	97.9	3.03	84.9	2.23	86.5	1.3	99.0
Filtered	I-7	7.2	91.1	8.0	92.2	18.8	92.4	0.32	98.4	2.49	87.6	1.83	88.9	2.0	98.5
Neutralized	J-2	21.7	73.2	24.7	76.3	53.8	78.2	1.23	93.9	13.5	32.8	11.3	31.5	13.4	89.5
Adsorbed	J-4	14.1	82.6	12.6	87.9	28.9	88.3	0.40	98.0	12.0	40.3	11.0	33.3	3.1	97.6
Adsorbed	J-6	8.13	90.0	8.2	92.1	18.1	92.7	0.39	98.0	12.1	39.8	10.5	36.4	1.7	98.7
Filtered	J-7	5.1	93.8	3.6	96.6	11.3	95.4	0.23	98.9	10.3	48.8	9.81	40.5	1.7	98.7

*%R - Percent removal

System 2, May-September 1975 Study--

A process schematic of pilot treatment System 2 is shown in Figure 4. The low-lime clarification system operated under approximately the same conditions as during the System 1 sampling period. Solids were wasted from the system at 2-3% of the total flow.

Clarified flow of 2.21 l/s is introduced to a biological nitrification basin with a detention time of 3.5 hours. Sludge is wasted from the system at an average rate of 0.116 l/s resulting in a sludge residence time (SRT) of about 17 days (range 10-18 days). Average volatile suspended solids concentration in the reactor is 2000 mg/l. Influent and effluent pH values are 9.9 and 7.2, respectively. Clarifier overflow rate is 5.94 $l/s/m^2$, which results in a detention time of 3.6 hours.

After methanol addition of 30 mg/l, the effluent is split to parallel denitrification columns at 1.10 l/s or 4.07 $l/s/m^2$. The columns are backwashed every 24 hrs. Denitrified effluent is fed in a downflow mode to four activated carbon columns operated in series at a rate of 0.5 $l/s/m^2$. Total empty bed contact time is 26 minutes. Columns are backwashed after 4 days of operation. Carbon column backwash includes 5 min of air wash at 1.5 $m^3/m^2/min$ followed by 15 min of low flow backwash (15% bed expansion) and 7.5 min of high flow backwash (30% bed expansion) at 8.83 $l/s/m^2$.

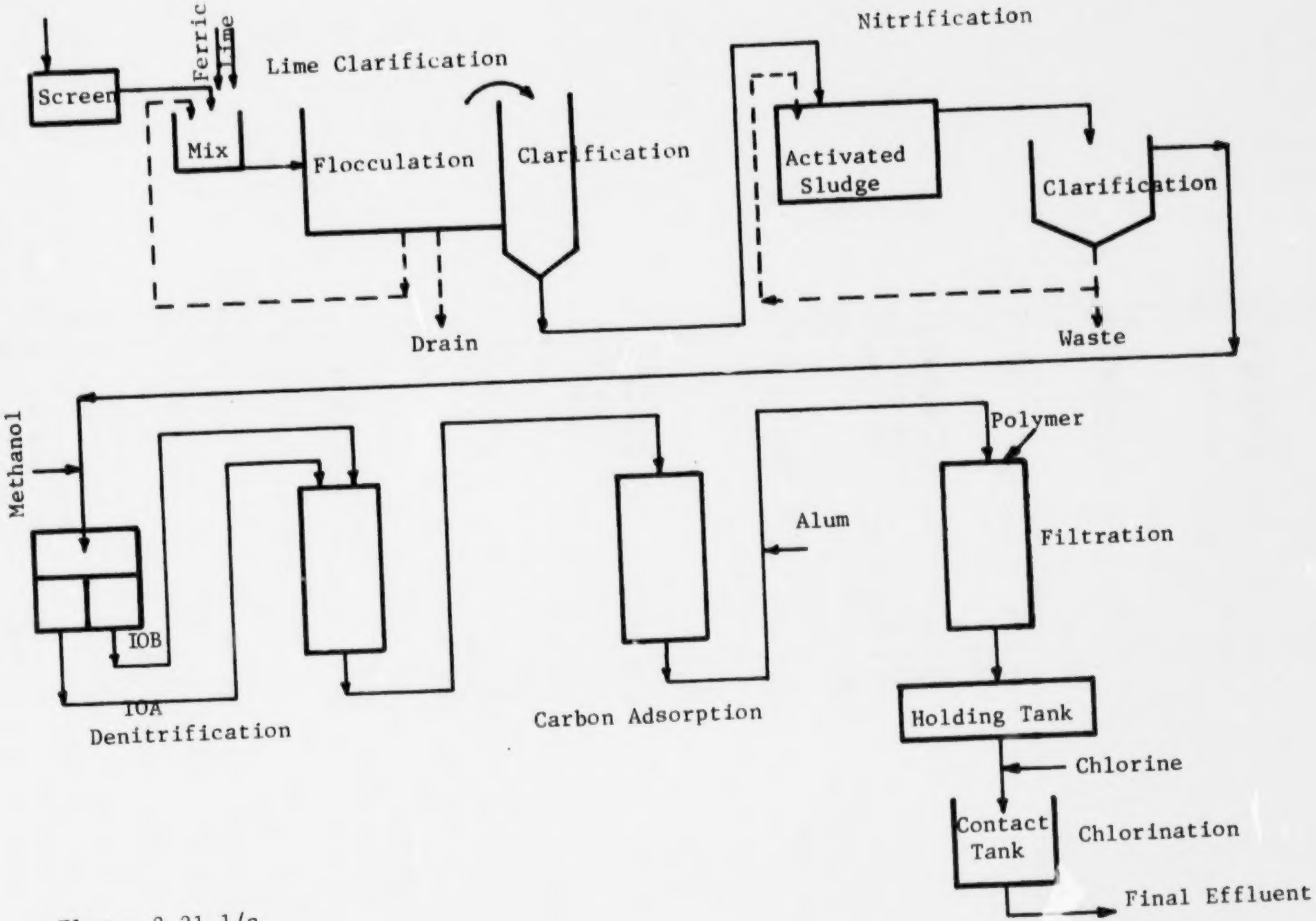
After alum addition, the carbon column effluent is distributed between three parallel dual media filters. Filter medium consists of 70 cm of 1.2 to 1.4 mm coal and 30.5 cm of 0.6 to 0.7 mm sand. A flow of 1.10 l/s/filter is treated at a rate of 0.2 $l/s/m^2$/filter. Filters are backwashed after 2 days of operation. The backwash system includes surface wash (0.945 l/s) and low flow (4.41 l/s), high flow (7.56 l/s) backwash.

Chlorine is added to the filtered effluent at a dose of approximately 5 mg/l for disinfection. Dosage is based on attaining a residual free chlorine of 1 mg/l in the effluent after 20 minutes.

Removal efficiency for selected performance parameters over the study period (May-September 1975) are summarized in Table 6. All processes were relatively stable and reliable during the sampling period. During April 1975, no coliforms were detected in the final effluent and the total plate count, based on 5 days of analysis, averaged 70/100 ml. Color was less than 5 and the turbidity averaged 0.6 turbidity units. As expected, both the lime clarification and denitrification systems increased removal efficiency with increased temperature.

Effluent Quality Goals

System 1 was designed to meet the discharge requirements for the Potomac River in the Washington, D.C., area that must be met by the full scale 13.5 m^3/s (309 mgd) Blue Plains wastewater treatment facility. These requirements limit effluent BOD_5, phosphorus, and total Kjeldahl nitrogen to 5 mg/l, 0.22 mg/l, and 2.4 mg/l, respectively. System 2 was designed to produce an effluent suitable for reuse which approached potable water quality.


Screen
Ferric
Lime
Mix
Lime Clarification
Flocculation
Clarification
Drain
Nitrification
Activated Sludge
Clarification
Waste
Methanol
IOB
IOA
Denitrification
Carbon Adsorption
Alum
Polymer
Filtration
Holding Tank
Chlorine
Contact Tank
Chlorination
Final Effluent

Flow - 2.21 l/s

Figure 4. System 2 schematic, Blue Plains.

TABLE 6. SYSTEM 2 BLUE PLAINS, MAY - SEPTEMBER 1975

Type of	TOC		BOD		COD		TPO_4		TKN		NH_3-N		NO_2+NO_3-N		SS	
Effluent	mg/1	%R*	mg/1	%R	mg/1	%R	mg/1	%R	mg/1	%R	mg/1	%R	mg/1	%R	mg/1	%R
Raw	65	--	82	--	211	--	13	--	17	--	16	--	0.1	--	100	--
Lime Clarified	20	69	29	65	62	71	1	29	11	29	11	31	0.1	--	17	83
Nitrified	6	91	5	94	16	92	0.8	94	0.7	96	0.2	99	10	--	8	92
Denitrified	5	92	2	98	16	92	0.3	98	0.8	95	0.2	99	2	80	3	97
Adsorbed	2	97	1	99	6	97	0.2	98	0.4	98	0.1	99	2	80	1	99
Filtered	2	97	1	99	6	97	0.1	99	0.3	98	0.1	99	2	80	1	99
Disinfected	2	97	3	96	6	97	0.1	99	0.2	99	0.1	99	2	80	1	99

*% R = Percent Removal

POMONA, CALIFORNIA

General Description

The pilot scale wastewater treatment systems studied at Pomona further treat the effluent from the Pomona wastewater renovation plant that includes the processes of primary sedimentation, activated sludge, and final clarification. Treatment of the full scale biologically stabilized effluent consists of activated carbon adsorption followed by three treatment sequences in parallel: (1) chlorination, (2) chlorination followed by activated carbon, or (3) ozonation followed by activated carbon. Composite samples from each of these three treatment systems (except where indicated) were collected according to the schedule in Table 7.

In addition, samples were concentrated for recovery of organic materials by reverse osmosis on September 25 and October 2, 1974, and June 17, 1975. Virus sampling was performed on November 11 and 12, 1974; and November 4, 5, 6, and 7, 1975.

Influent Characteristics

The raw wastewater is comprised of approximately 90% municipal by volume, and some paper product waste. Industrial contributors are diversified. Metal plating wastes have been present due to industrial upsets, but have not caused major operational problems. Table 8 presents the raw wastewater characteristics reported during the study period.

Treatment Systems

A raw wastewater flow of 0.35 m^3/s is first treated by primary sedimentation, followed by activated sludge and final clarification. This treatment results in an effluent characterized by a COD of 35 mg/l, 10-15 mg/l TOC, 10 mg/l suspended solids, 10 mg/l BOD_5, and a variable level of ammonia (0-20 mg/l) depending on the degree of biological nitrification.

A downflow carbon adsorption system treats 6.31 l/s of the secondary effluent. The hydraulic loading rate is 2.38 l/s/m and contact time is 10 min. The column is 1.83 m in diameter, 4.98 m high, and maintains a 1.52 m bed depth.

After initial carbon adsorption, one of three unit operation sequences completes treatment for 3.15 l/s of the waste:

System 1 - chlorination
System 2 - chlorination followed by activated carbon
System 3 - ozonation followed by activated carbon

A schematic illustrating the system configurations, effluent sampling locations, and operating conditions is shown in Figure 5.

TABLE 7. COLLECTION OF COMPOSITE SAMPLES - POMONA

System 1 (Chlorination)	System 2 (Chlorination followed) by Activated Carbon	System 3 (Ozonation followed by Activated Carbon
September 20, 1974	September 25, 1974	September 23, 1974
October 1, 1974	September 27, 1974	September 25, 1974
October 7, 1974	October 9, 1974	October 24, 1975
October 21, 1974	October 23, 1974	November 4, 1975
November 11, 1974	November 23, 1974	November 6, 1975
December 6, 1974	December 6, 1974	February 11, 1976
April 24, 1975	September 12, 1975	March 12, 1976
September 16, 1975	September 19, 1975	March 4, 1976
November 7, 1975	September 24, 1975	March 16, 1976

TABLE 8. POMONA RAW WASTE CHARACTERIZATION
(Sampling Period: May 1974 to June 1975)

Parameter	Average Value
Suspended solids (mg/l)	200
Total COD (mg/l)	320
Dissolved COD (mg/l)	50
Total Phosphate (mg/l as P)	11.1
pH	7.7
Alkalinity (mg/l as $CaCO_3$)	217
Calcium (mg/l)	51
Magnesium (mg/l)	10.9
Potassium (mg/l)	10.5
Sodium (mg/l)	100
Chloride (mg/l)	104
Sulfate (mg/l)	95
MBAS (mg/l)	2.0
Phenol (mg/l)	0.17
TDS (mg/l)	573

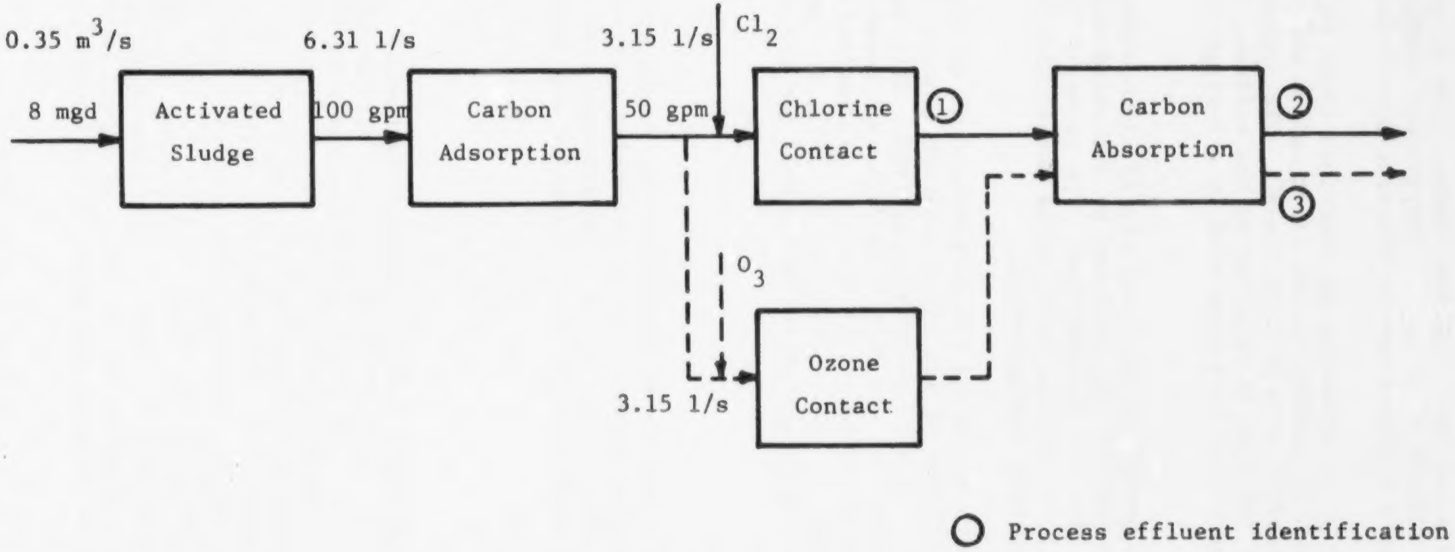

0.35 m^3/s
8 mgd
Activated Sludge
6.31 l/s
100 gpm
Carbon Adsorption
3.15 l/s
50 gpm
Cl_2
Chlorine Contact
①
Carbon Absorption
②
③
O_3
3.15 l/s
Ozone Contact
○ Process effluent identification

Figure 5 . Flow diagram, Pomona pilot plant.

System 1 involves a 1.5 hour chlorine contact time at a dosage level of 12 mg/l and resultant residue of 10 mg/l. Operational problems have been experienced with periodic fluctuations of chlorine dose levels.

System 2 consists of chlorination as described above and carbon adsorption. The carbon column is similar to the first column with a 10 min contact time and a hydraulic loading rate of 2.38 $l/s/m^2$. The system is operated with gravity feed. No chlorine is detected in the effluent after this adsorption step. Spent carbon is regenerated by a 6-stage multihearth furnace (926.7°C).

System 3 involves ozonation employing six 15.25-cm diameter columns with a total of 21 min contact time followed by activated carbon. A 30 mg/l ozone dosage level is used for disinfection. The ozone is fed into the bottom of each column in a parallel mode, while the liquid flows downward, with the columns in a series configuration.

Plant personnel were comparing the performance of the three systems to produce a virus-free effluent of low total coliform content (below 2.2 per 100 ml) as part of their on-site program objectives. Efforts were made to monitor ammonia, chlorine, and COD data from various process units, but inorganic characterizations were not of concern. Summarized operating data for the periods September 1, 1975 - November 30, 1975, and December 1, 1975 - April 30, 1976, are presented in Tables 9-12 for the respective treatment systems.

Effluent Quality Goals

Systems 1 through 3 were being studied at the Pomona pilot plant facility to compare their respective performances in achieving a virus-free effluent with total coliforms below 2.2 per 100 ml. Anticipated uses of the effluent from future full-scale facilities are for irrigation and industrial purposes.

DALLAS, TEXAS

General Description

Both primary and secondary 6.3 l/s advanced wastewater treatment pilot plants in Dallas, Texas can treat effluent from the city's trickling filter wastewater treatment plant. The pilot system incorporates the unit operations of activated sludge, secondary clarification, upflow high lime clarification, recarbonation, mixed media filtration, carbon adsorption, and chlorination. Samples of process effluent were composited over a period extending from noon of one day to noon of the following day. Composite samples were collected on September 4, 1974; September 12, 1974; October 16, 1974; October 21, 1974; December 13, 1974; January 24, 1975, and January 29, 1975. A grab sample was collected on October 4, 1974. Samples for concentration by reverse osmosis were collected on October 3-5, 1974, and December 10-12, 1974. Virus samples were taken on September 13 and December 10 and 11, 1974.

TABLE 9. SUMMARY OF WATER QUALITY CHARACTERISTICS THROUGH TREATMENT SYSTEMS 1 and 2 - POMONA (September 1 - November 30, 1975)

		System 1		System 2	Removal %		
Water Quality[a] Parameters	Secondary Effluent	First Stage Carbon Effluent	Chlorine Contactor Effluent	Second Stage Carbon Effluent	First Stage	Chlorine Contactor	Second Stage
NH_3-N, mg/1[b]	0.57	0.81	12.3	11.4			
NO_2-N, mg/1	0.19	0.11	0.08	0.53			
NO_3-N, mg/1	10.6	10.2	8.7	11.5			
pH	7.5	7.4	7.5	7.3			
Temperature, °C	23.5						
Suspended Solids, mg/1	7.3	3.0	1.7	1.4	58.9	43.3	17.6
Turbidity, FTU	3.2	1.0	1.0	0.9	68.8		
Color	29	8	4	2	72.4	50.0	50.0
Total COD, mg/1	28.8	13.2	12.6	6.4	54.2	4.5	49.2
Dissolved COD, mg/1	21.3	9.9	10.4	4.7	53.5		54.8
TDS, mg/1	563		546	547			
Alkalinity, mg/1	148	161	153	146			

[a] Based on 16 hr composite samples; NH_3, NO_2^-, NO_3^-, and temperature were run on grab samples.

[b] Ammonium chloride was added to the chlorine contactor influent.

TABLE 10. SUMMARY OF WATER QUALITY CHARACTERISTICS THROUGH TREATMENT SYSTEM 3 - POMONA (September 1 - November 30, 1975)

Water Quality[a] Parameters	Secondary Effluent	First Stage Carbon Effluent	Ozone Contactor Effluent	Second Stage Carbon Effluent	Removal % First Stage	Removal % Ozone Contactor	Removal % Second Stage
NH_3-N, mg/1[b]	0.21	0.04	0.06	3.7			
NO_2^--N, mg/1	0.26	0.22	0.11	1.1			
NO_3^--N, mg/1	10.9	10.5	11.0	10.9			
pH	7.5	7.5	7.7	7.4			
Temperature, °C	23.7						
Suspended Solids, mg/1	7.6	1.5	1.2	1.0	80.3	20.0	16.7
Turbidity, FTU	3.4	0.8	0.6	0.7	76.5	25.0	
Color	28	10	4	1	64.3	60.0	75.0
Total COD, mg/1	30.9	13.7	12.5	5.1	55.7	8.8	59.2
Dissolved COD, mg/1	21.5	11.2	11.0	3.5	47.9		68.2
TDS, mg/1	551		538	529			
Alkalinity, mg/1	157	163	159	141			

[a] Based on 16-hr composite samples; NH_3, NO_2^-, NO_3^-, and temperature were run on grab samples.

[b] Ammonium chloride was added to the chlorine contactor influent.

TABLE 11. SUMMARY OF WATER QUALITY CHARACTERISTICS THROUGH TREATMENT SYSTEMS 1 and 2 - POMONA (December 1, 1975 - April 30, 1976)

		System 1		System 2			
Water Quality[a] Parameters	Secondary Effluent	First Stage Carbon Effluent	Chlorine Contactor Effluent	Second Stage Carbon Effluent	Removal % First Stage	Removal % Chlorine Contactor	Removal % Second Stage
NH_3-N, mg/l[b]	7.0	6.4	17.2	17.3			
NO_2^--N, mg/l	1.3	1.1	0.9	0.9			
NO_3^--N, mg/l	4.5	3.4	4.3	4.4			
pH	7.3	7.4	7.3	7.3			
Temperature, °C	17.7						
Suspended Solids, mg/l	6.5	1.5	0.9	1.3	76.9	40.0	
Turbidity, FTU	3.0	1.1	1.0	0.9	63.3		
Color	30	13	9	1	56.7	30.8	88.9
Total COD, mg/l	37	18	16	8	51.4	11.1	50.0
Dissolved COD, mg/l	28	16	15	6	42.9		60.0
TDS, mg/l	500		484	482			
Alkalinity, mg/l	2--	188	162	168			

[a] Based on 16 hr sample; NH_3, NO_2^-, NO_3^-, and temperature were grab samples.

[b] Ammonium chloride was added to the first-stage carbon effluent.

TABLE 12. SUMMARY OF WATER QUALITY CHARACTERISTICS THROUGH TREATMENT SYSTEM 3 - POMONA
(December 1, 1975 - April 30, 1976)

Water Quality[a] Parameters	Secondary Effluent	First Stage Carbon Effluent	Ozone Contactor Effluent	Second Stage Carbon Effluent	Removal %		
					First Stage	Ozone Contactor	Second Stage
NH_3-N, mg/1[b]	5.1	6.2	8.7	10.1	-	-	-
NO_2-N, mg/1	1.7	1.8	1.0		-	5	-
NO_3-N, mg/1	5.8	5.3	6.2		9	-	-
pH	7.3	7.3	7.5	7.3	-	-	-
Temperature, °C	20.5				-	-	-
Suspended Solids, mg/1	9.4	3.9	2.4	1.6	59	38	3
Turbidity, FTU	3.2	1.9	1.3	0.8	41	32	38
Color	33	18	5	3	46	72	40
Total COD, mg/1	43	26	24	12	40	8	50
Dissolved COD, mg/1	31	22	19	9	29	14	53
TDS, mg/1	514		513	504	-	-	-
Alkalinity, mg/1	199	186	182	170	6	2	7

[a] Based on 16-hr sample; NH_3, NO_2^-, NO_3^-, and temperature were grab samples.

[b] Ammonium chloride was added to the first-stage carbon effluent.

Influent Characteristics

Raw wastewater is comprised of approximately 88% municipal waste by volume. About 35% of the BOD and suspended solids loading result from 221 major industrial and 1700 commercial users. The industrial clientele is very diversified; film processing, plating, and meat packing dischargers are included. No major petrochemical industry discharges waste into the system. Characteristics of raw wastewater received at the city's full-scale trickling plant during the months of study (September, October, and December 1974 and January 1975) are presented in Table 13. As indicated, the raw wastewater can be classified as a medium strength waste (5). After undergoing primary clarification, the wastewater served as the influent to the pilot system.

TABLE 13. RAW WASTEWATER INFLUENT CHARACTERIZATION
(Dallas, Texas)

Determination	Average Over Study	Sewage Strength*
Suspended Solids (mg/l)	211	M-W
COD (mg/l)	432	-
BOD (mg/l)	199	M
TOC (mg/l)	153	-
Total P (mg/l)	10.6	-
Total N (mg/l)	28.9	W-M
NH_3-N (mg/l)	11.8	W
Org. N (mg/l)	16.8	M-W
NO_2, NO_3 (mg/l)	0.3	M
pH	7.3	-

*Classified according to Babbitt and Baumann (5), where M = medium, and W = weak.

Treatment Sequence

Figure 6 illustrates the process configuration and operating conditions during the September 1974 sampling. During the period of this project, the pilot plant was treating primary effluent from the full-scale plant. After primary clarification, a flow of 10 l/s is treated by a nitrifying activated sludge process with a mixed liquor volatile suspended solids (MLVSS) concentration of approximately 2400 mg/l and a sludge age of 14 days. Process control and hydraulic parameters for the months of study are summarized in Tables 14 and 15.

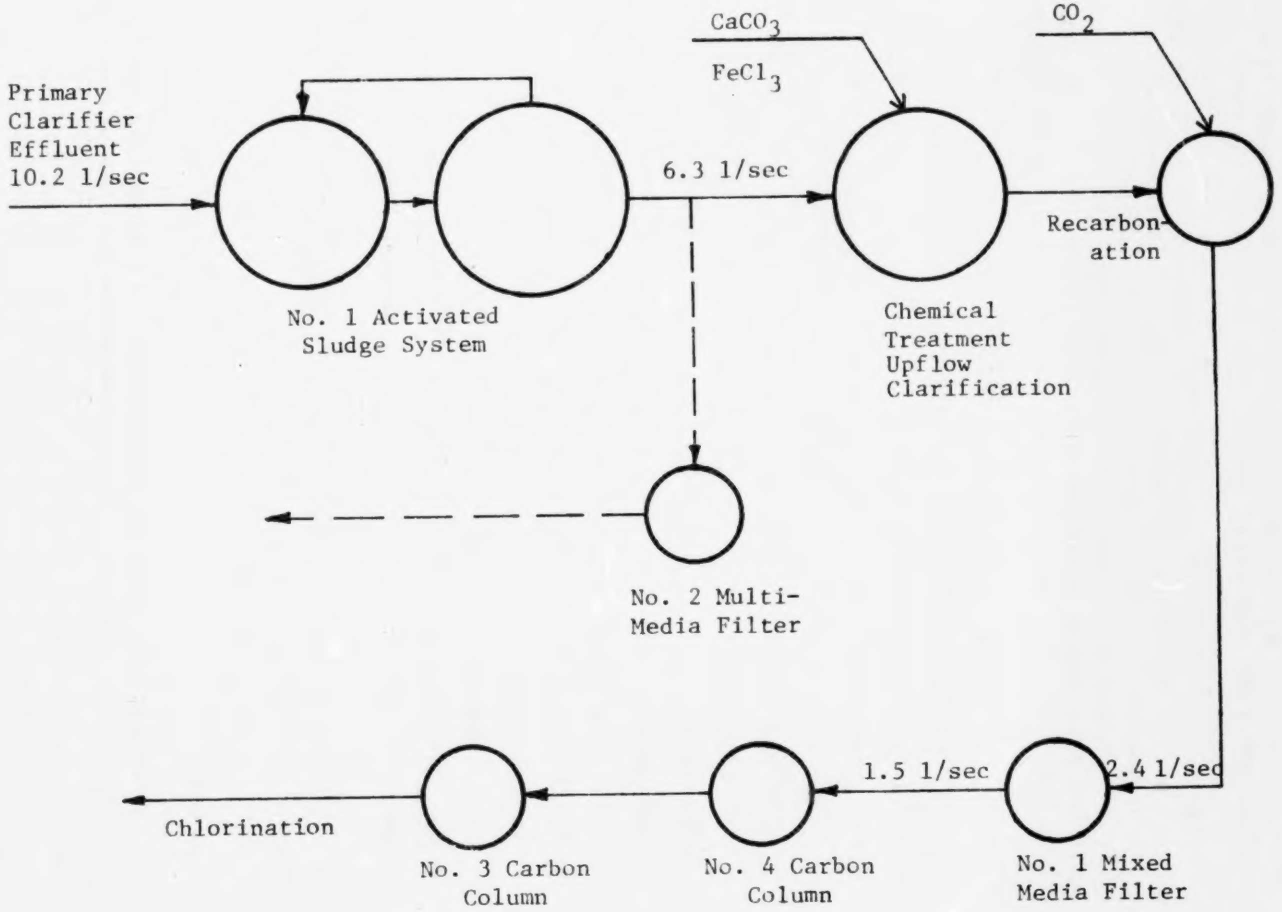

Primary
Clarifier
Effluent
10.2 l/sec
No. 1 Activated
Sludge System
6.3 l/sec
$CaCO_3$
$FeCl_3$
Chemical
Treatment
Upflow
Clarification
CO_2
Recarbon-
ation
No. 2 Multi-
Media Filter
2.4 l/sec
No. 1 Mixed
Media Filter
1.5 l/sec
No. 4 Carbon
Column
No. 3 Carbon
Column
Chlorination

Figure 6. Process configuration--September 1974, Dallas.

TABLE 14. PROCESS CONTROL PARAMETERS
(Nitrifying Activated Sludge System, Dallas)

Control Parameter	Average Value
Mixed Liquor Suspended Solids (MLSS)(mg/1)	3403
Mixed Liquor Volatile Suspended Solids (MLVSS)(mg/1)	2438
MLVSS/MLSS	0.71
F/M BOD (g BOD_5 applied/day/g MLSS)	0.255
F/M COD (g COD applied/day/g MLSS)	0.419
F/M TOC (g Soluble TOC applied/day/g MLSS)	0.062
F/M NH_3N (g NH_3-N applied/day/g MLSS)	0.024
F/M TKN (g TKN applied/day/g MLSS)	0.038
Sludge Age (days)	14.1
Sludge Volume Index (SVI)	174
Mixed Liquor DO Uptake Rate (mg/1/hr)	23.6
Return Sludge DO Uptake Rate (mg/1/hr)	31.2
Aeration Basin DO (mg/1)	3.1
Average Temperature (°C)	22

TABLE 15. HYDRAULIC PROCESS CONTROL
(Activated Sludge System, Dallas)

Hydraulic Parameter	Average Value
Flow, Q (1/s)	10.2
Recycle Flow, Q (1/s)	11.8
Detention Time, T (hours)	4.7
T with Recycle, $Q+Q_R$ (hours)	2.2
Clarifier T (hours)	6.6
Clarifier T, $Q+Q_R$ (hours)	3.0
Overflow Rate ($1/s/m^2$)	7.30
Weir Loading ($1/s/m^2$)	59.12

The effluent is split and a flow of 6.3 l/s from the activated sludge process is chemically treated by an Infilco Densator® upflow clarifier with a 6-hour retention time. Lime and ferric chloride are employed as coagulants. Respective concentration dosages are approximately 232 mg/l and 15 mg/l. A single stage recarbonation basin follows the upflow clarifier. About 237 g of CO_2 per cubic meter results in a decrease from pH 10.9 to pH 6.4.

After recarbonation, a portion of the wastewater (2.4 l/s) is treated by a mixed media filter (Neptune Microfloc media) for removal of suspended solids and other associated matter. The filter is operated at a hydraulic loading rate of 2.31 l/s/m^2 and a backwash rate of 12.22 l/s/m^2 for sufficient media cleaning.

Approximately 1.5 l/s of the filtered wastewater is pumped to two carbon adsorption units operated in series. Empty bed contact time is 100 minutes and flow is in the downflow mode.

After carbon adsorption, a chlorine contact stage is employed with a 2-hour detention time and a chlorine addition level of approximately 13 mg/l.

Effluent Quality Goals

The pilot plant is designed to produce an effluent that approaches potable quality. Performance data for the system during the period covered by this project are summarized in Tables 16 and 17.

TABLE 16. METALS REMOVAL SUMMARY - DALLAS

Metal	Primary Effluent (mg/l)	A.S. Effluent (mg/l)	Filter Effluent (mg/l)	Carbon Column Effluent (mg/l)	Net Percent Reduction
As*	30	17	4	2	93
B	0.30	0.35	0.37	0.39	--
Ba	0.19	0.10	0.16	0.16	16
Cd	0.015	0.009	0.004	0.003	80
Cr	0.068	0.026	0.010	0.010	85
Cu	0.139	0.030	0.086	0.043	69
Fe	0.566	0.44	0.094	0.087	85
Hg*	0.21	0.19	0.21	0.13	38
Mn	0.068	0.042	0.010	0.01	85
Pb	0.078	0.033	0.042	0.032	59
Se*	3.43	2.03	0.57	0.50	85
Zn	0.109	0.067	0.063	0.050	54

*Micrograms/liter

During the period of study two major plant upsets were experienced. The first of these involved the operation of the mixed media filter during September. The backwash rate (8.96 l/s/m^2) was not sufficient to properly clear the media. A channeled filter bed resulted. Breakthrough occurred

TABLE 17. PERFORMANCE SUMMARY - DALLAS

Parameter	Raw Wastewater	Primary Effluent	A.S. Effluent	Clarification, Recarbonation Effluent	Mixed Media Filter Effluent	Carbon Column Effluent	Overall Percent Reduction
Suspended Solids (mg/1)	211	103	28	32	3.6	1.6	99.2
BOD_5 (mg/1)	199	155	14	2	--	2	99.0
COD (mg/1)	432	259	50	20	18	4	99.1
TOC (mg/1)	153	41*	12*	11.6*	10.9	6.7	95.6
NH_3-N (mg/1)	11.8	15.3	5.0	4.4	4.0	3.6	69.5
Org N (mg/1)	16.8	8.0	3.5	2.0	1.9	0.9	94.6
TKN (mg/1)	28.6	23.3	9.0	6.4	5.9	4.5	84.3
NO_2 & NO_3-N (mg/1)	0.3	0.4	5.1	4.9	4.9	5.1	--
Total N (mg/1)	28.9	23.7	14.1	11.3	11.6	10.0	65.4
Total P (mg/1)	10.6	8.7	5.8	0.44	0.44	0.41	96.1
pH	7.3	7.1	7.3	6.9	6.9	7.0	--
Alkalinity (mg/1 as $CaCO_3$)	--	237	149	257	279	271	--
Hardness (mg/1 as $CaCl_3$)	--	182	166	287	279	284	--
Turbidity (JTU)	--	54	9	10.7	2.0	1.1	--
TC/100 ml	--	7.4×10^7	2.5×10^6	1.4×10^3	9.9×10^3	590	--
FC/100 ml	--	2.2×10^7	5.1×10^5	75	803	95	--
F^- (mg/1)	--	1.3	1.3	--	1.1	1.3	--
Sp. Cond (μmhos)	--	809	710	912	916	905	--
Cl^- as NaCl (mg/1)	--	--	109	--	--	131	--
SO_4^{-2} (mg/1)	--	--	98	98	94	--	--
TDS (mg/1)	--	--	479	622	--	608	--
Color (mg/1)	--	--	--	--	14.5	0.8	--

*Soluble TOC

between September 11-18, 1974. The backwash water flow rates were increased to 12.2 $l/s/m^2$, and no subsequent difficulties were experienced. Although a sample for analysis was collected during this upset period (September 12, 1974), no significant affects on final effluent were apparent due to the inherent buffer capacity of subsequent treatment processes. Effluent suspended solids concentrations for September were not used in determining average performance efficiency, as shown in Table 17.

Upsets with the activated sludge process were encountered in December. A hydraulic washout of the biomass occurred because of an improperly calibrated flow meter. Biomass levels dropped from 3210 mg/l to 250 mg/l mixed liquor suspended solids (MLSS). Addition of ferric chloride prompted recovery; normal operation was attained by December 20.

ESCONDIDO, CALIFORNIA

General Description

Wastewater is first treated biologically by a 13.1 l/s contact stabilization plant. Approximately 8.51 l/s of clarified effluent is polished by mixed media filtration, followed by reverse osmosis. Samples of final process effluent were collected on July 8, 1975.

Influent Characteristics

Approximately 86.5% of the raw wastewater is of domestic origin. The remaining 13.5% is from industrial discharges; electronics is the major industrial contributor. Table 18 illustrates the raw wastewater characteristics as received at the secondary treatment facility.

TABLE 18. ESCONDIDO RAW WASTEWATER CHARACTERISTICS

Parameter	Average Value (July, 1975)
pH	7.6
Biochemical Oxygen Demand (BOD_5) (mg/l)	198
Suspended Solids (mg/l)	197
Total Dissolved Solids (TDS, mg/l)	1372
Temperature (°C)	23.3
Grease & Oil (mg/l)	23.4
Phenol (mg/l)	0.023
Chloride (mg/l Cl^-)	339
Ammonia Nitrogen (mg/l)	39.4
Total Nitrogen (mg/l)	52.0

Treatment Sequence

Figure 7 illustrates the process configuration and operation during the July 8 sampling. After secondary treatment of 13.1 l/s by a biological contact stabilization package treatment plant and subsequent clarification, 8.5 l/s of effluent is treated by mixed media filtration. Effluent from the

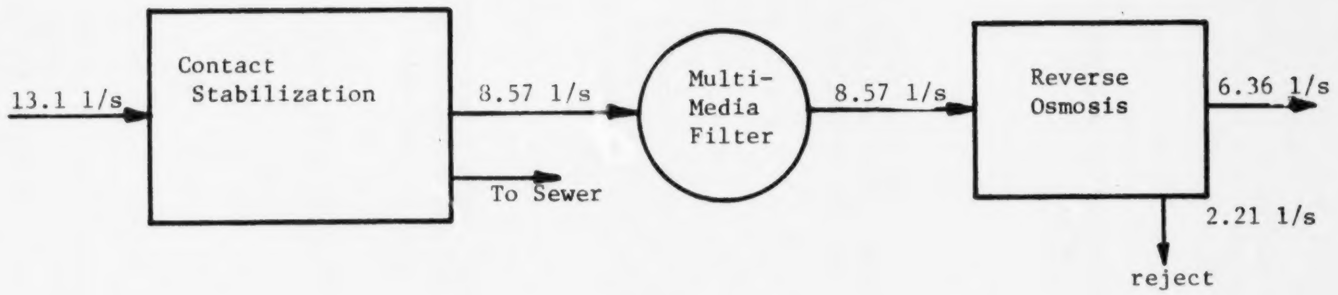

13.1 1/s
Contact
Stabilization
8.57 1/s
To Sewer
Multi-
Media
Filter
8.57 1/s
Reverse
Osmosis
6.36 1/s
2.21 1/s
reject

Figure 7. Process flow sequence, Escondido, California.

filtration unit is characterized by a conductivity of 2190 μmhos, turbidity of 1 JTU, pH of 5.7, and temperature of 25.5°C. A pH of 5.7 is maintained to minimize precipitation and consequent membrane fouling and to prolong the life of the reverse osmosis membrane. Following filtration, the wastewater is treated by a reverse osmosis unit operating at a pressure of 22.44 atm. Product flow is 6.36 l/s with a rejection of 2.21 l/s. Conductivity of the feed, product, and brine are 2190, 158, and 8050 μmhos, respectively.

Effluent Quality Goals

The Escondido, California, pilot plant is designed to produce an effluent suitable for ground water recharge.

ORANGE COUNTY, CALIFORNIA

General Description

This 0.657 m^3/s plant, operated by the Orange County Water District and designated Water Factory 21, processes municipal wastewater that has received prior treatment by primary clarification and trickling filtration at the Orange County sanitation district plant. The advanced wastewater treatment processes include lime coagulation, ammonia stripping, two-stage recarbonation, mixed media filtration, activated carbon adsorption, and chlorination. Samples were collected during the months of January through March 1976. Samples of AWT plant effluents were composited from 0800 of one day to 0800 of the following day and were analyzed by GSRI. Samples were collected on the following dates: February 10, 12, 17, and 18; March 7, 9, and 11, 1976. Samples for organic concentration were taken on January 27 and February 3, 1976.

Influent Characteristics

The raw wastewater received at the Orange County sanitation district plant contains 30% industrial wastes that are composed of pretreated metal plating and refining wastes. Data on the raw wastewater characteristics are shown in Table 19.

TABLE 19. ORANGE COUNTY RAW WASTEWATER CHARACTERISTICS

Parameter	Average Value (Jan-Mar., 1976)
Suspended Solids (mg/l)	415
Volatile Suspended Solids (mg/l)	307
Biochemical Oxygen Demand (mg/l)	275
pH	7.8
Ammonia Nitrogen (mg/l)	60
Silver (mg/l)	0.019
Cadmium (mg/l)	0.023
Chromium (+6) (mg/l)	0.360
Copper (mg/l)	1.10
Lead (mg/l)	0.45
Zinc (mg/l)	1.10

Treatment Sequence

A flow diagram of the reclamation process is shown in Figure 8. The unit operations system is designed as two parallel trains, each capable of treating one-half of the design flow.

Trickling filter effluent is treated initially in a high-lime clarification system which is composed of separate rapid mix, flocculation, and sedimentation basins. Retention times are 1 minute (each basin), 30 minutes,

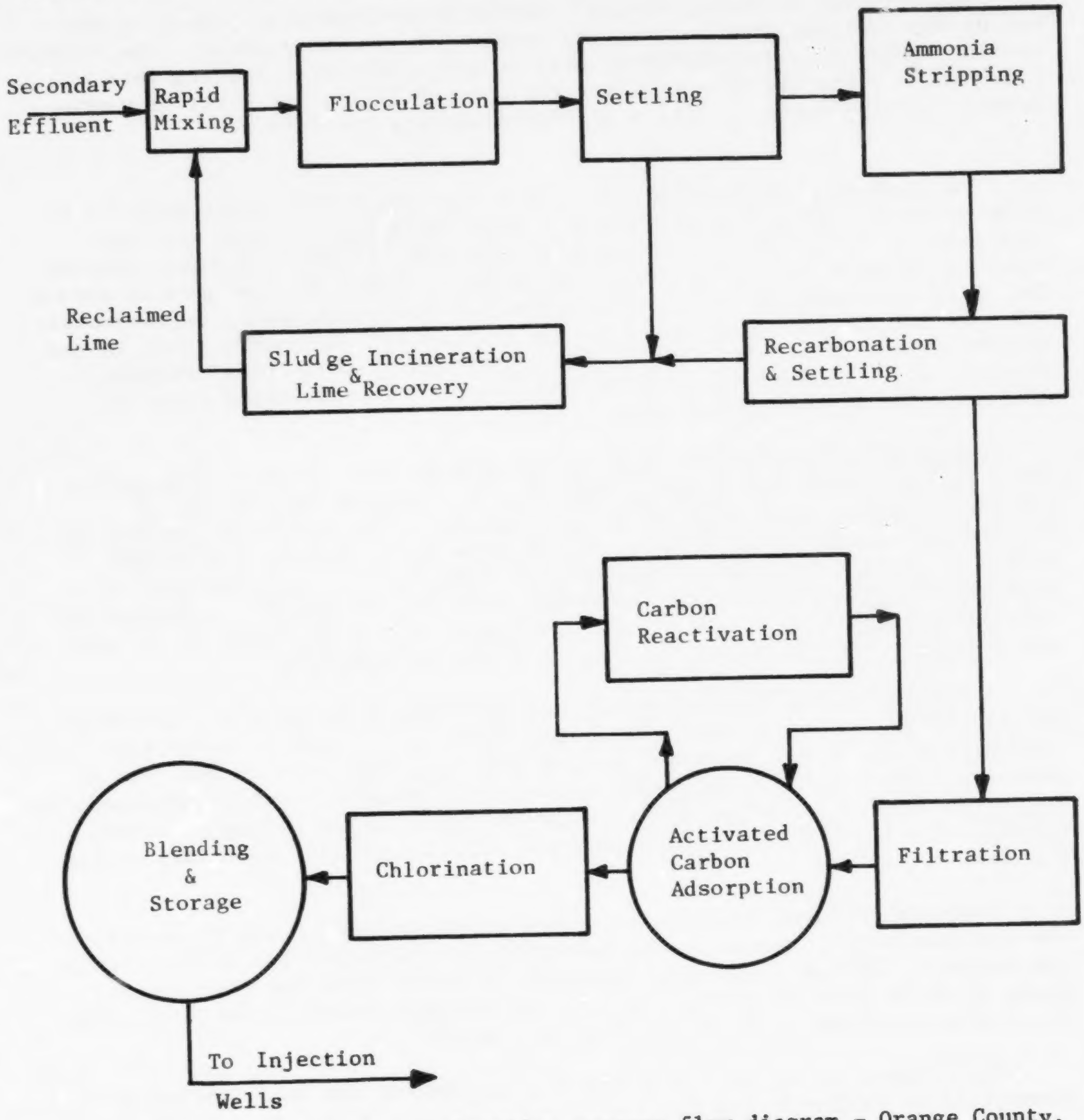

Secondary Effluent
Rapid Mixing
Flocculation
Settling
Ammonia Stripping
Reclaimed Lime
Sludge Incineration & Lime Recovery
Recarbonation & Settling
Carbon Reactivation
Blending & Storage
Chlorination
Activated Carbon Adsorption
Filtration
To Injection Wells

Figure 8. Wastewater reclamation process flow diagram - Orange County.

and 85 minutes, respectively. Clarifier overflow rate is 17.63 $l/s/m^2$. Each settling basin is equipped with settling tubes to obtain a lower suspended solids level in the effluent. Lime in dosages of 425 to 540 mg/l is added as primary coagulant to the rapid mix basin to achieve a pH greater than 11.0. In addition, Dow A-23 polymer is added to the third stage flocculation basin at dosages ranging from 0.1 to 0.25 mg/l to improve settling. The clarification process reduces COD, phosphate, and turbidity to acceptable levels (5).

The effluent from the chemical clarification basins is pumped to the top of the cooling/ammonia stripping towers for ammonia removal. The countercurrent towers have induced-draft airflow and a hydraulic loading rate of 0.679 $l/s/m^2$; the air flow to water ratio is 49.11 l/s per liter of wastewater. Packing depth is 7.62 m and fan diameters are 5.49 m.

The high pH of the wastewater (11) is decreased to a level near 7.5 by a two-stage recarbonation unit which incorporates intermediate settling. This process is intended to increase recovery of calcium carbonate, thereby reducing hardness and total dissolved solids. Carbon dioxide used to reduce the pH is furnished by lime recalcination furnace stack gases; approximately 317.5 kg per day of CO_2 is added to the wastewater. Detention times in the recarbonation and settling basins are 15 minutes (each), and 40 minutes, respectively. Sludges generated are thickened and centrifuged prior to recalcination at high temperature.

Recarbonation basin effluent passes through open, gravity flow multimedia filters. The filter media beds are 76.2 cm deep and consist of stratified coarse coal, silica, and garnet sand. The supporting medium is layered silica and garnet with a Leopold underdrain system. The filter system is designed to operate in parallel. Each of the four filters has a capacity of 0.164 m^3/s with a throughput rate of 3.40 $l/s/m^2$. Backwash is effected at a rate of 10.18 $l/s/m^2$. Alum and polymer are added at 15 mg/l and 0.05 mg/l, respectively, to enhance turbidity removal.

Activated carbon adsorption follows mixed-media filtration. Seventeen parallel carbon columns, each containing 40.82 metric tons of activated carbon, operate in the pressure, upflow mode. Carbon depth in the 3.66 m diameter columns is 7.32 m. Contact time is 30 minutes, with a corresponding hydraulic loading of 3.94 $l/s/m^2$. Regeneration of spent carbon is accomplished by a multihearth furnace having a capacity of 5443 kg of dry carbon per day.

Polished effluent from the activated carbon columns flows by gravity to the chlorine contact basin for disinfection and for oxidation of any remaining ammonia. Contact time is 30 minutes. Effluent from the chlorination basin flows by gravity to the blending and storage reservoir and is blended 50:50 with desalted water and/or deep well water.

Performance of the AWT reclamation plant during the study period is summarized in Tables 20 and 21.

TABLE 20. PERFORMANCE CHARACTERISTICS - ORANGE COUNTY WATER FACTORY 21
(February and March, 1976)

Parameter	AWT Influent	Clarifier Effluent	Ammonia Tower Effluent	Filter Effluent	Carbon Effluent	Final Effluent Following Chlorination
pH	7.7	11.4				6.7
Turbidity (JTU)	22.8	1.9				0.8
Conductivity (µmhos)	1785.7	-				1452.1
Ca (mg/1)	102.4	151.4				118.3
Mg (mg/1)	24.8	1.2				-
Na (mg/1)	201.0	-				239.4
Cl (mg/1)	225.9	-				-
SO_4 (mg/1)	334.5	-				356.1
PO_4-P (mg/1)	5.4	0.12				-
CO_3 (mg/1)	1.6	91.6				0.0
OH (mg/1)	0.0	230.2				0.0
HCO_3 (mg/1)	284.4	0.0				142.0
Org N (mg/1)	2.1	1.5				0.85
NH_3-N (mg/1)	-	47.0	22.2	-		23.6
TOC (mg/1)	-	-	-	15.2	6.8	-
COD (mg/1)	107.2	52.6	-	42.4	11.1	-
T H ($CaCO_3$)						288.4
F (mg/1)						0.68
B (mg/1)						0.62

TABLE 21. HEAVY METAL REMOVAL - ORANGE COUNTY WATER FACTORY 21
(February and March, 1976)

Metal Analysis (μg/l)	AWT Influent	Clarifier Effluent	Filter Effluent	Carbon Effluent
Ag	4.48	1.31	1.22	1.20
As	2.02	1.16	1.01	1.02
Ba	80.50	35.08	26.62	25.54
Cd	6.84	2.20	1.74	1.13
Cr^{+6}	235.76	122.52	110.94	64.18
Cu	305.76	105.30	93.58	18.14
Fe	221.4	15.44	33.38	179.88
Hg	0.29	0.26	0.35	0.32
Mn	39.17	2.11	2.17	4.17
Pb	26.62	11.46	11.38	10.58
Se	7.36	7.49	7.42	7.40
Zn	292.18	36.56	709.33	139.88

Effluent Quality Goals

The Orange County AWT plant is designed to produce an effluent suitable for groundwater injection. The injected reclaimed wastewater blended with desalted seawater will be used to prevent seawater from flowing into the groundwater basin. Regulatory agency requirements for the injection water are listed in Table 22.

TABLE 22. REGULATORY AGENCY REQUIREMENTS FOR INJECTION WATER
Orange County Water Factory 21

Constituent	Maximum Concentration (mg/l)
Ammonium	1.0
Sodium	110.0
Total hardness ($CaCO_3$)	220.0
Sulfate	125.0
Chloride	120.0
Total nitrogen (N)	10.0
Fluoride	0.8
Boron	0.5
MBAS	0.5
Hexavalent Chromium	0.05
Cadmium	0.01
Selenium	0.01
Phenol	0.001
Copper	1.0
Lead	0.05
Mercury	0.005
Arsenic	0.05
Iron	0.3
Manganese	0.05
Barium	1.0
Silver	0.05
Cyanide	0.02
Electrical conductivity	900 µmhos/cm
pH	6.5 - 8.0
Taste	None N
Odor	None
Foam	None
Color	None
Filter effluent turbidity	1.0 JTU
Carbon adsorption column effluent COD	30 mg/l
Chlorine contact basin effluent	Free chlorine residual

SECTION 4

DETAILS OF ANALYTICAL PROGRAM

The detailed discussion of the analytical program is divided into two main areas: (1) preparation of the organic concentrate samples, isolated by reverse osmosis, extractions, and solvent evaporations, and (2) characterization of the treatment system effluents with respect to parameters used to determine potable quality water.

REVERSE OSMOSIS CONCENTRATION

Reverse osmosis is one of the few processes which remove and concentrate organic materials from large volumes of water and at the same time retain the major portion of organics originally present in the sample. In reverse osmosis, a semipermeable membrane separates two isolated solution compartments as illustrated in Figure 9. Osmosis is defined as the flow of solvent through a membrane and results from the drive to equalize any concentration difference between the solutions in the two compartments. If the solute concentration is greater in the concentration compartment and if the membrane is permeable only to solvent, the solvent will flow from the permeate compartment into the concentrate compartment. This arrangement dilutes the solution in the concentrate compartment and equalizes the concentrations. The net pressure ($P_1 - P_2$) which must be exerted to stop the osmotic flow of solvent is defined as the osmotic pressure. If the net pressure is increased until it is greater than the osmotic pressure, the flow of solvent will be reversed; solvent will flow from the concentrated solution to the more dilute solution, further concentrating the sample. This state of the system is defined as reverse osmosis (RO). A more complete discussion of membrane separation of organics in drinking water is available (4).

For this project, a reverse osmosis system was designed to utilize the broad retentive abilities of a combination of two different membranes to concentrate the organics in effluent from advanced waste treatment systems. By recirculating the plant effluent through the concentrate compartments at a pressure greater than the osmotic pressure, the volume of effluent is reduced and the sample concentrated. The basic components of this reverse osmosis system are shown in Figure 10. The system consists of two recirculating reverse osmosis subsystems in series; the permeate from the first is feed for the second. The effluent to be concentrated is therefore processed twice before being run to sewer. This system is capable of concentrating large volumes of water in a relatively short time. The sample volume reduction can be done with a typical average solute rejection of better than 90%.

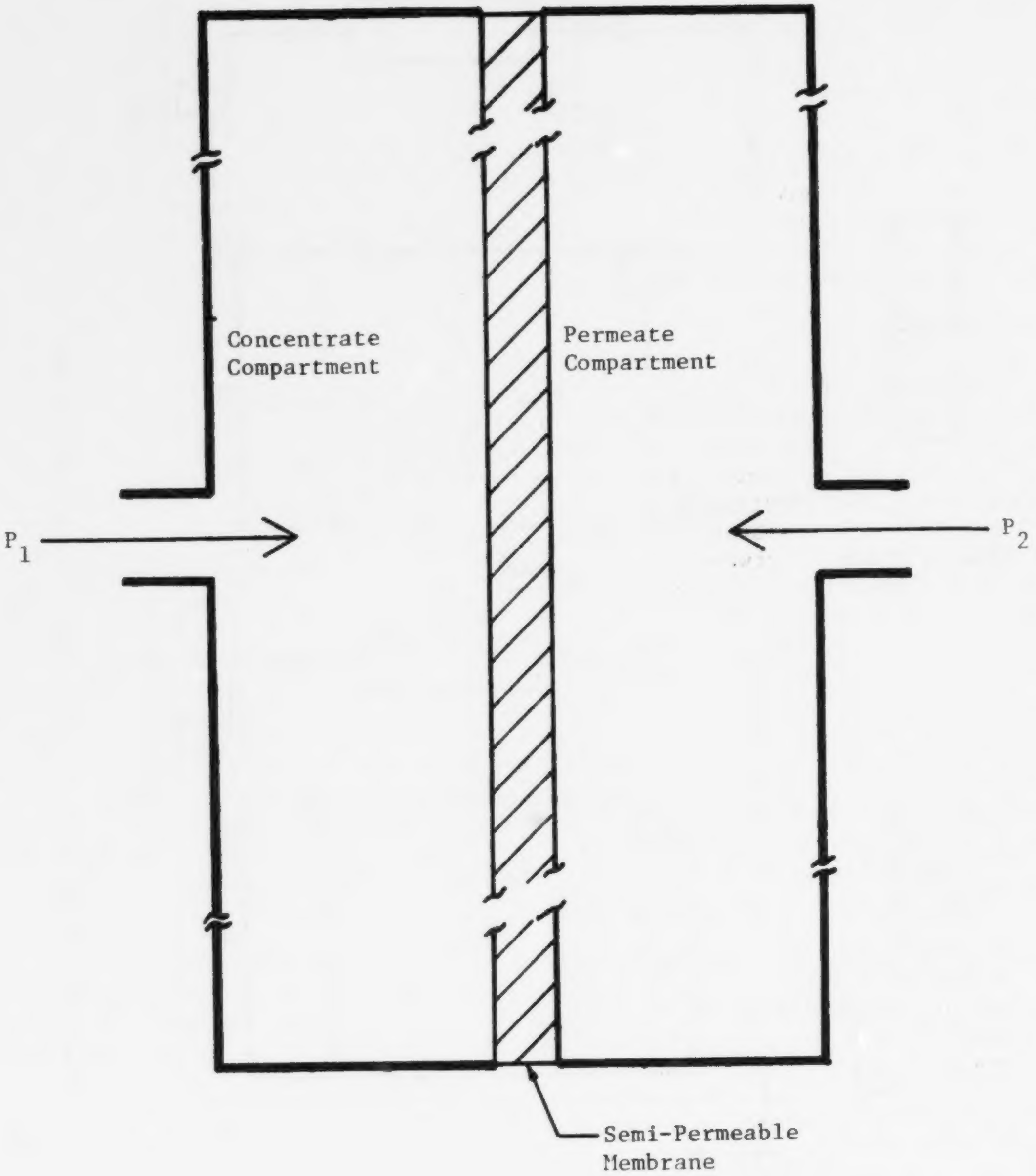

Concentrate
Compartment
Permeate
Compartment
P_1
P_2
Semi-Permeable
Membrane

Figure 9. Theoretical model of reverse osmosis operation.

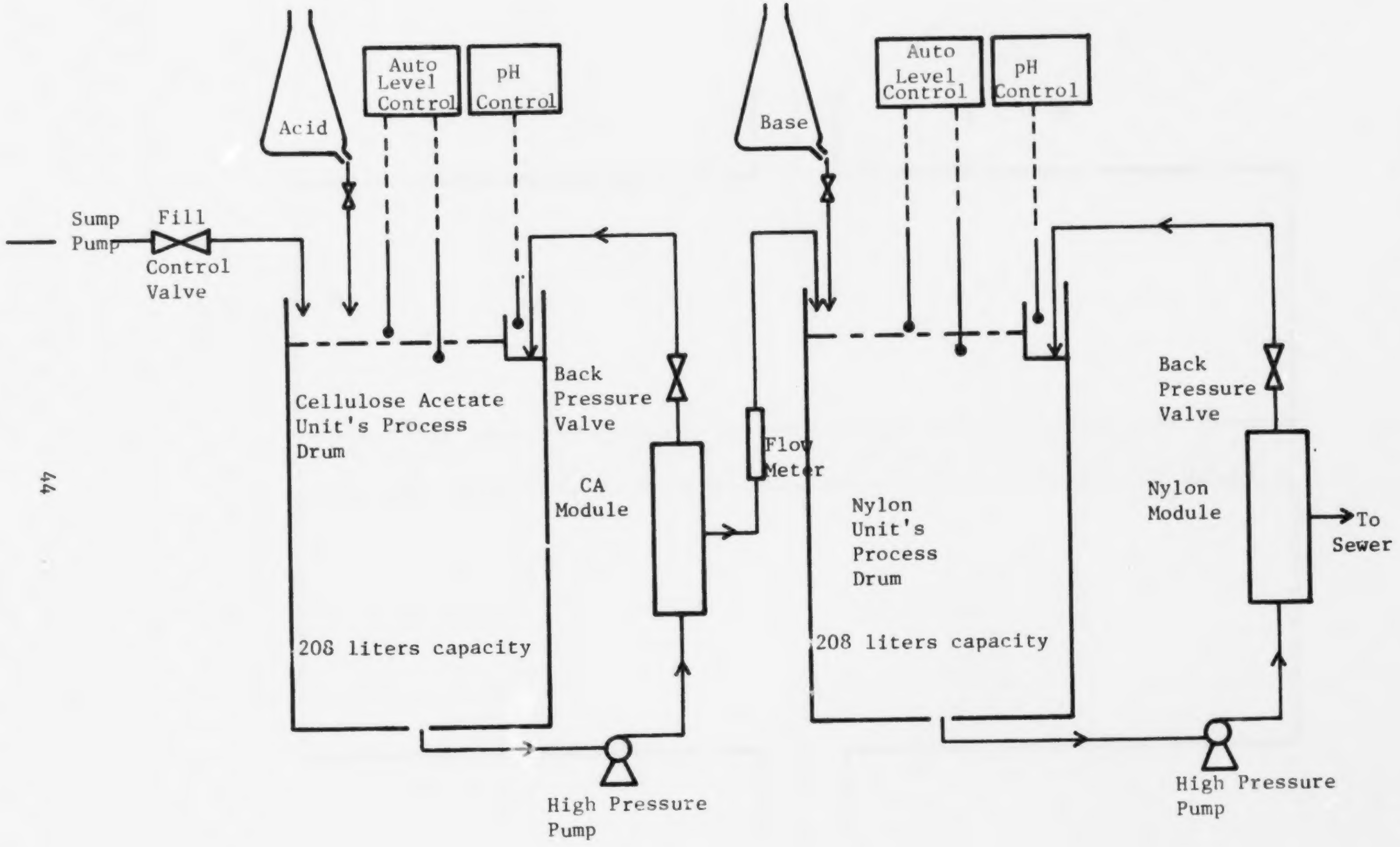

Sump
Pump
Fill
Control
Valve
Acid
Auto
Level
Control
pH
Control
Cellulose Acetate
Unit's Process
Drum
208 liters capacity
Back
Pressure
Valve
CA
Module
High Pressure
Pump
Flow
Meter
Base
Auto
Level
Control
pH
Control
Nylon
Unit's
Process
Drum
208 liters capacity
Back
Pressure
Valve
Nylon
Module
To
Sewer
High Pressure
Pump

Figure 10. Basic reverse osmosis concentrator used by GSRI

There are two additional advantages realized with this RO system. As with all reverse osmosis systems, the energy consumption is lower than that of some other water purification/concentration methods involving phase changes; e.g., distillation, freeze drying. Although energy was not a major concern in this project, the detrimental effects of large energy inputs were avoided. For example, the increased energy in other systems often is in the form of increased solution temperatures which can cause a loss or transformation of certain organics. There is little temperature increase in the reverse osmosis system.

The second advantage of the designed system was mobility. Two complete reverse osmosis systems were used: one by GSRI personnel, the other by NISR personnel. The GSRI equipment was contained in a small portable trailer which could be moved from location to location. The NISR unit was similar except that the process drums were too large to be moved conveniently from site to site. Therefore, the effluent water had to be transported to the concentrator for processing. The two reverse osmosis systems are shown in Figures 10 and 11. Samples for the concentrations were collected according to the schedule in Table 23.

TABLE 23. ORGANIC CONCENTRATE SAMPLE COLLECTION DATES

Sample Number	Sampling Code	Date
1	Lake Tahoe I	September 5, 1974
2	Blue Plains I	September 19-21, 1974
3	Pomona I	September 25, 1974
4	Pomona II	October 2, 1974
5	Dallas I	October 3-5, 1974
6	Lake Tahoe II	October 24, 1974
7	Dallas II	December 10-12, 1974
8	Blue Plains II	May 29 - June 1, 1975
9	Pomona III	June 17, 1975
10	Escondido	July 8, 1975
11	Orange County I	January 27, 1976
12	Orange County II	February 3, 1976

Description of Concentration Processes

Mobile System--

Figure 10 represents the GSRI portable system. There are two recirculating subsystems, each with a 208 liter (55 gallon) process drum for retaining the two concentrates. The subsystem centered around the cellulose acetate membrane is the first to process the plant effluent. The permeate from the cellulose acetate membrane is reprocessed by a DuPont Permeasep® nylon based

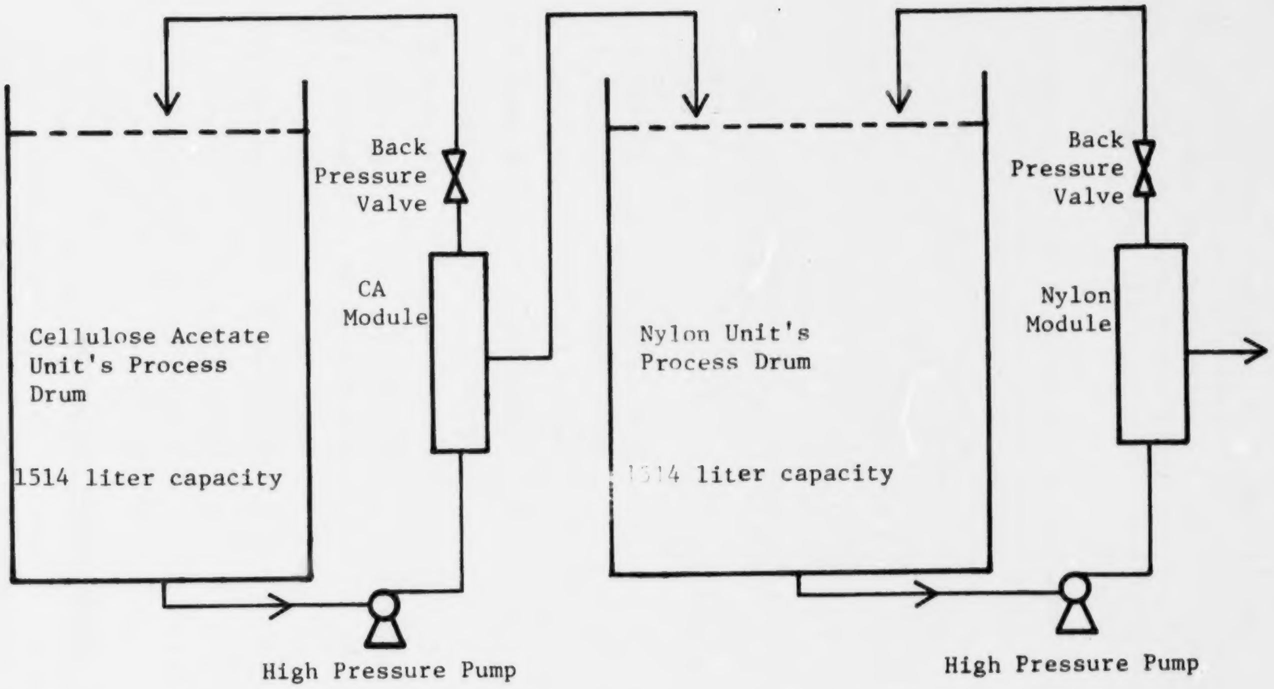

Back
Pressure
Valve
CA
Module
Cellulose Acetate
Unit's Process
Drum
1514 liter capacity
High Pressure Pump
Nylon Unit's
Process Drum
1514 liter capacity
Back
Pressure
Valve
Nylon
Module
High Pressure Pump

Figure 11.Reverse osmosis concentrator used by NISR membrane. Water permeating the nylon membrane is run to waste. In this procedure, two concentrates are generated: one retained by the cellulose acetate membrane and one retained by the nylon membrane. The process drums are maintained at a full level until the total volume of water to be processed has been taken in. At that time the sump (feed) pump is turned off. The solution level is automatically regulated; a conductance-based level controller and probes control the fill valve on the cellulose acetate subsystem and both high pressure pumps on the nylon subsystem. This arrangement controls solution levels and permits automatic system operation as long as the sump pump is running. The only other controls are the pH and pressure controls for each subsystem.

Because fresh effluent is being added continually to the system, and because of possible preferential treatment of H^+ or OH^- by the membranes, pH control is necessary to maintain the cellulose acetate system at pH 5.5 and the nylon subsystem at pH 10.0. The pH controller regulates a valve which meters acid or base as needed.

The operating pressures for each subsystem are maintained at 13.6 atm by manipulation of the back pressure valves.

When the total amount of water has been reduced to approximately 189.25 liters, the sump pump is shut off and the level of concentrate in the process drum is further reduced to approximately 38 liters. At this point, the cellulose acetate membrane subsystem is shut off, initiating the drop of solution level in the nylon membrane subsystem. The nylon unit's concentrate also is reduced in volume to approximately 38 liters.

Stationary System--

The samples collected from pilot plants on the West Coast were collected by employees of NISR under direction of Dr. Paul Cantor. The equipment used was functionally the same as the mobile unit used by GSRI personnel, except that the process drums on the NISR system were much larger as shown in Figure 11. Cellulose acetate processing was in one large batch so that there was no need for level control equipment. Adjustment of pH was manual. Water was transported from the pilot plants to NISR in clean, stainless steel drums.

The following sections describe the sequence of steps required to secure the aqueous concentrates from the plant effluents.

Reverse Osmosis System Flushing

The GSRI group used the following pretreatment procedure for each concentration: Upon arriving at an AWT plant site, the reverse osmosis system was filled with plant effluent, run for 15 - 30 minutes, and drained. This was repeated two times. The units were then set up to operate automatically for 12-24 hours. At the end of this flush period all solutions were drained and the system was set for automatic operation.

Prior to the concentration of each sample the NISR group flushed the stationary system with tap water for at least five hours, purging the modules of preservatives.

Sample Acquisition

The GSRI group towed the reverse osmosis system to the site of the AWT plant to be tested. After the initial flush period, the reverse osmosis system processed fresh effluent at approximately 18.9 - 37.8 liters per hour. This rate was maintained until the total volume, 1514 - 1892 liters, was processed.

The NISR group visited each plant and filled eight clean stainless steel drums with plant effluent. The drums and water were transported to NISR and pumped into the clean cellulose acetate reverse osmosis process drum.

Sample Concentration

The process criteria for reverse osmosis processing of the concentrates did not vary throughout the study. The pH of the cellulose acetate subsystem was maintained at 5.5 and the pH of the nylon subsystem at 10.0. Pressure for both subsystems was approximately 13.6 atm.

In addition to pH and pressure, membrane rejections (based on solution conductivities), solution temperatures, and TOC values were monitored occassionally during the sample reverse osmosis concentration.

When the process drum was filled with plant effluent, the high pressure reverse osmosis pumps were started. The pressure was adjusted by manipulating the back pressure valve. The rate of water permeation through the cellulose acetate membrane usually ranged from 18.9 - 37.8 liters per hour. The GSRI nylon subsystem started as soon as enough water had permeated the cellulose acetate membrane to fill the process drum of the nylon unit. The nylon subsystem at NISR was run intermittently at the operator's discretion. Pressures were adjusted by the back pressure valve.

Level controllers on the GSRI system maintained drum volume at about 189 liters. This was done by automatic control of the fill valve-sump pump combination on the cellulose acetate subsystem. On the nylon subsystem, solution level was maintained by on-off control of the high pressure pump.

Control of pH was automatic on the GSRI system; the pH of NISR system was controlled manually. On the GSRI system, when processing of the total volume was complete, the sump pump was shut off, and the solution level in the cellulose acetate process drum dropped. The unit was manually shut off and drained when the volume was reduced to approximately 18.9 - 37.8 liters. Volume of the nylon subsystem then decreased. When a level of 18.9 - 37.8 liters was attained, this subsystem was also shut off and drained.

The NISR reverse osmosis system reduced the samples from each subsystem to approximately 151 liters. Samples were air freighted to GSRI for further volume reduction to 18.9 - 37.8 liters. All final aqueous concentrates were iced down for transport and stored in a cooler at 4°C prior to laboratory workup.

Table 23 lists the 12 AWT plants for which effluent waters were concentrated under this program and the dates of those samplings. Numbers have been assigned to each sample for future reference in the report.

ORGANIC SOLVENT EXTRACTIONS AND EVAPORATIONS

The aqueous concentrates isolated by reverse osmosis contained a high salt burden in addition to organics. Since these concentrates were to be used in another EPA project involving toxicity studies and identification of specific organics, the inorganic salt burden had to be reduced. Solvent extraction was used to achieve this reduction.

The procedure used in sample workup was basically the same throughout the project. Exceptions are noted below. The original extraction procedure suggested by the EPA (Table 24) was used for the first seven samples listed in Table 23. Two procedural modifications, approved by the Project Officer, were effected after sample number 7, Dallas II.

In the first modification, the number of extraction steps performed with each solvent was increased. The samples prepared from each solvent extract were split into two portions: 80 percent (by volume) to be used for toxicological studies and 20 percent for chemical characterization. The toxicological fractions were combined before drying. This procedure (Table 25) was used on samples 8, 9, and 10.

In the second modification, a vacuum distillation step was added to the sample workup. This procedure, detailed in Table 26, had been adopted in a similar project (EPA 68-03-2367), and was designed to improve retention of organics during the removal of milliliter quantities of methylene chloride and pentane. This procedure was used for the last two sets of samples, Orange County I and II.

The samples are listed in Table 27 with the extraction method used for the preparation of each organic concentrate. Six organic concentrates were prepared from samples 1-7, three from the product of the cellulose acetate and three from the nylon unit. An additional sample was prepared on samples 8-12 due to the 80/20 split. The 20 percent portions of the six extracts were kept separate for chemical analysis and the 80 percent portions were combined and dried by the procedures outlined in Tables 25 and 26.

All samples were shipped to Dr. Frederick Kopfler, EPA, Cincinnati, for disposition. At the time of this report, portions of the samples had been sent to Stanford Research Group for mutagenic studies, which have been completed. Further analytical work may be performed as a result of the data from these mutagenic studies.

TABLE 24 . INITIAL EXTRACTION PROCEDURE FOR RO CONCENTRATES

1. If precipitated salts are present, remove by filtration. Lyophilize salts, crush, and extract three times with pentane followed by three extractions with methylene chloride. Concentrate extracts as described below for concentration of extracts of aqueous phase (Note 1).

2. For each liter of concentrate add 75 ml of pentane and extract for 10 minutes. If the extraction is conducted in an Erlenmeyer flask with a magnetic stirrer, the rate of mixing should be just fast enough to disperse the pentane.

3. Separate the pentane from the aqueous layer (Note 2).

4. Extract the aqueous concentrate two more times with 50 ml pentane/liter for three minutes each time. Combine all pentane extracts.

5. Dry the combined pentane extract by adding 7 g of anhydrous sodium sulfate/500 ml pentane and allow to stand overnight (Note 3).

6. Concentrate the extract in a Kuderna-Danish apparatus to a volume of 5 - 10 ml.

7. Concentrate to 1 ml by placing the tube in a water bath (40-50°C) under a gentle stream of dry nitrogen.

8. Extract the aqueous phase just as before, using methylene chloride instead of pentane. Treat extracts as before.

9. Adjust the aqueous phase to a pH=2 with HCl.

10. Extract as before with methylene chloride.

NOTES

Note 1: All glassware should be solvent rinsed immediately before use and the solvent discarded.

Note 2: Breaking emulsions can be accomplished by passing the emulsified extract through a 2.5 cm column (no frit) containing a 2.5 cm ball of glass wool. After wetting the wool with fresh extraction solvent and discarding this rinse, pour the emulsion through the glass wool. Ignore the debris that remains. It may be necessary to force the emulsion through with a little air pressure. After the emulsion is broken, inspect the extract. If two distinct layers are present, separate the aqueous phase from solvent before drying the solvent phase.

Note 3: Before using anhydrous sodium sulfate for the drying of extracts it should be heated to 500°C for two hours and stored in a glass stoppered bottle.

TABLE 25. MODIFIED EXTRACTION PROCEDURE FOR RO CONCENTRATES

1. If precipitated salts are present, remove by filtration. Lyophilize salts, crush, and extract three times with pentane followed by three extractions with methylene chloride. Concentrate extracts as described below for concentration of extracts of aqueous phase (Note 1, Table 24).

2. Add 1/10 the total volume (total volume = 7% of aqueous concentrate) of pentane to the concentrate using the apparatus shown in Figure 12. When the layers have separated, draw off the solvent with a large pipette.

3. Separate the pentane from the aqueous layer (Note 2, Table 24).

4. Extract the aqueous concentrate 2 more times using 1/10 the total volume of pentane each time. Combine all pentane extracts.

5. Dry the combined pentane extract by adding 7 g of anhydrous sodium sulfate/500 ml pentane and allow to stand overnight (Note 3, Table 24).

6. Concentrate the extract in a Kuderna-Danish apparatus to a volume of 5 - 10 ml.

7. Concentrate to 1 ml by placing the tube in a water bath (40-50°C) under a gentle stream of dry nitrogen.

8. Extract the aqueous phase just as before, using methylene chloride instead of pentane. Treat extracts as before.

9. Adjust the aqueous phase to a pH =2 with HCl.

10. Extract as before with methylene chloride.

11. Split each of the six 1-ml samples from step 7 (three from the cellulose acetate concentrate and three from the nylon concentrate) into two fractions: one 0.2 ml sample to be used for analysis and 0.8 ml to be used for the toxicological sample (step 12).

12. Combine all six 0.8 ml samples along with rinses and dry with clean, dry nitrogen gas at 40°-50°C.

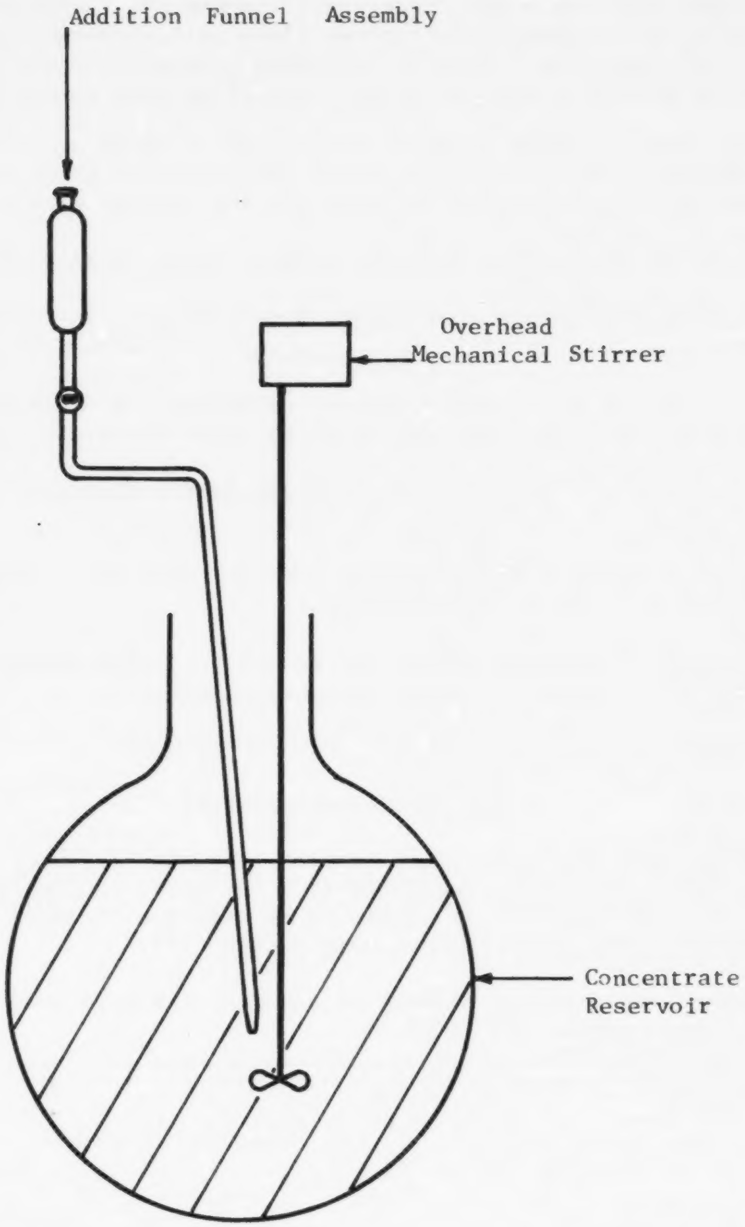

Addition Funnel Assembly
Overhead Mechanical Stirrer
Concentrate Reservoir

Figure 12. Assembly for extraction of organics from water concentrate.

TABLE 26. FINAL EXTRACTION PROCEDURE FOR RO CONCENTRATES

1. If precipitated salts are present, remove by filtration. Lyophilize salts, crush, and extract three times with pentane followed by three extractions with methylene chloride. Concentrate extracts as described below for concentration of extracts of aqueous phase.

2. Add 1/10 the total volume (total volume = 7% of aqueous concentrate) of pentane to the concentrate using the apparatus shown in Figure 11. When the layers have separated, draw off the solvent with a large pipette.

3. Separate the pentane from the aqueous layer (Note 2, Table 24).

4. Extract the aqueous concentrate 9 more times using 1/10 the total volume of pentane each time. Combine all pentane extracts.

5. Dry the combined pentane extract by adding 7 g of anhydrous sodium sulfate/500 ml pentane and allow to stand overnight (Note 3, Table 24).

6. Concentrate the extract in a Kuderna-Danish evaporator to a volume of 2.0 ml. Separate this sample into two portions of 0.4 ml for GC-MS analysis and 1.6 ml for the toxicological sample (step 11).

7. Extract the aqueous phase just as before, using methylene chloride instead of pentane. Treat extracts as before.

8. Adjust the aqueous phase to a pH=2 with HCl.

9. Extract as before with methylene chloride.

10. Combine all 1.6 ml extract fractions from step 6 and rinses and remove excess solvent by vacuum distillation at 21" Hg vacuum and 50°C bath.

11. Dry combined sample at 40°-50°C with clean, dry nitrogen gas.

TABLE 27. PROCEDURES USED IN PREPARATION OF ORGANIC CONCENTRATES

Sample Number from Table 23	Extraction Procedure	Total Organic Concentrate Fractions Prepared
1	Table 24	6
2	Table 24	6
3	Table 24	6
4	Table 24	6
5	Table 24	6
6	Table 24	6
7	Table 24	6
8	Table 25	7
9	Table 25	7
10	Table 25	7
11	Table 26	7
12	Table 26	7

VIRUS CONCENTRATION

Collection and concentration of samples for virus analysis were performed under subcontract by the Carborundum Company. The contract required that 2 samples be collected at each of 6 AWT sites for a total of 12 samples. However, Carborundum was unable to obtain samples at Orange County, California, one of the desired sites, because of delayed start-up. A total of 23 samples were collected from the remaining 5 treatment plants. In all cases, samples were taken from treatment plant final effluent, except at the Pomona Research Facility, where waters were subjected to three alternate processes prior to sampling.

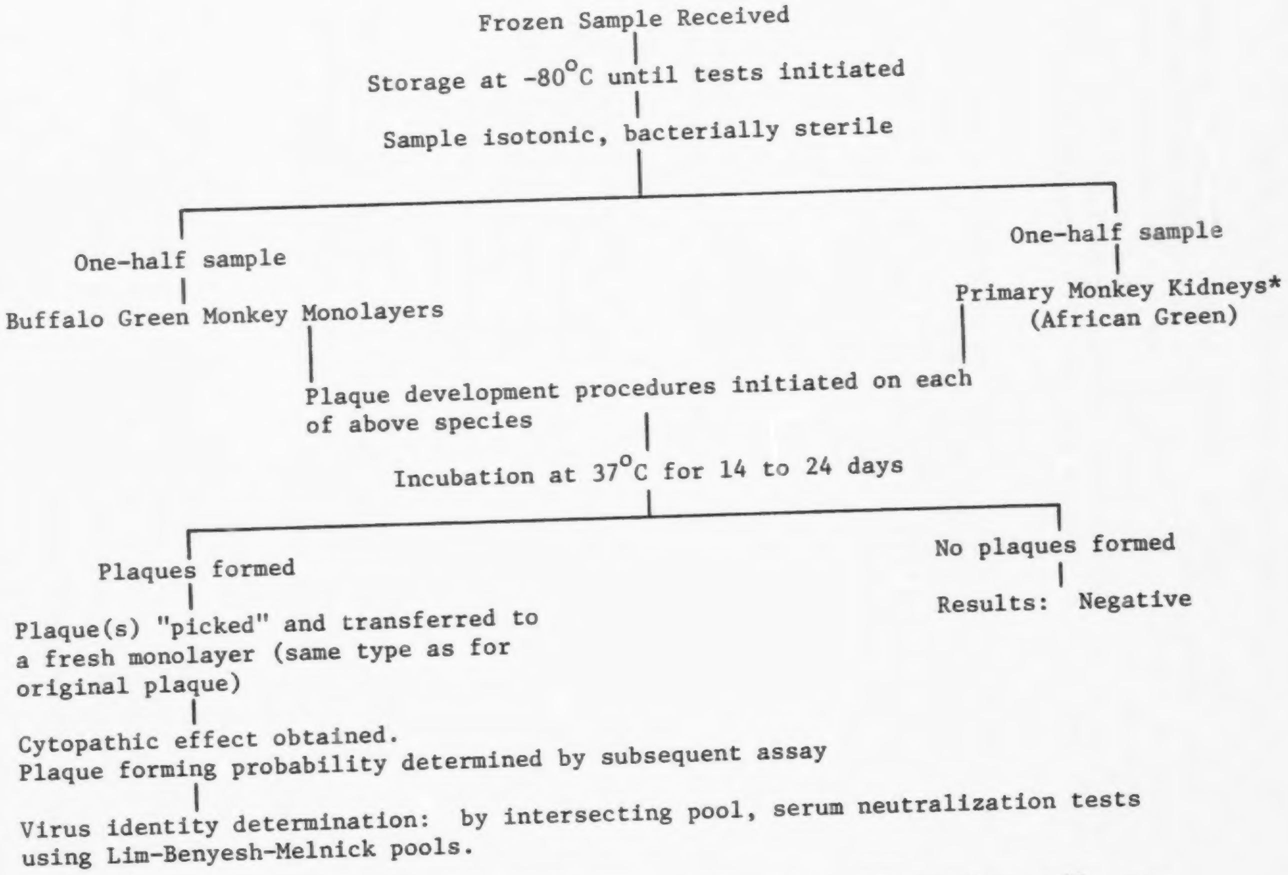
Field Sampling

The Carborundum Aquella® virus concentrator was used throughout the program for field processing of water samples. Typically, 378 liters of water was processed, and virus recovered in a 10-20 ml solution. Standard methodology (6) was used. The virus concentrator was transported to each sampling site, and concentration procedures were conducted in the field. A local power source was utilized in all cases.

Virus concentrates (10-20 ml) were frozen at dry ice temperature (-78°C) at the sampling station and were shipped by air freight to Carborundum's virus assay laboratory in New Hampshire. Federal and airline regulations and all requirements under Title 42 of the Public Health Laws were strictly followed.

Laboratory Assays

Samples were analyzed for virus content at the Jackson Estuary Laboratory, Durham, New Hampshire. The schematic in Figure 13 illustrates the route taken


Frozen Sample Received
Storage at -80°C until tests initiated
Sample isotonic, bacterially sterile
One-half sample
Buffalo Green Monkey Monolayers
One-half sample
Primary Monkey Kidneys*
(African Green)
Plaque development procedures initiated on each of above species
Incubation at 37°C for 14 to 24 days
Plaques formed
Plaque(s) "picked" and transferred to a fresh monolayer (same type as for original plaque)
Cytopathic effect obtained.
Plaque forming probability determined by subsequent assay
Virus identity determination: by intersecting pool, serum neutralization tests using Lim-Benyesh-Melnick pools.
No plaques formed
Results: Negative

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*Monolayers inoculated with sterile diluent and overlain with overlay media are used to control (a) monolayer integrity, (b) freedom from adventitious virus, and (c) bacterial contaminants in inoculum.

Figure 13. Sample laboratory analysis flow sheet.

by each sample within the laboratory. Until testing, each sample was maintained at -80°C to prevent denaturation and changes detrimental to virus recovery. Removal of bacteria, yeast and mold was accomplished by an 8-16 hr ether treatment using a 5-10 percent final concentration of ether.

Sample testing was split between two culture types, Buffalo Green Monkey (BGM) and Primary Monkey Kidney-African Green (PMK), to obtain as great an isolation sensitivity as possible. All examinations in cell cultures were made by means of plaquing, to separate individual viruses and obtain data on the number of viruses present. Cell culture incubation periods of up to 24 days maximized development of slow forming plaques, thus allowing recovery of natural viruses.

Following the formation of a plaque, virus was recovered by means of "plaque picks." The identified virus was then transferred to a fresh culture monolayer with an overlay medium. The monolayer was always of the same type as that used for the initial recovery. Identification of isolates was made by conventional intersecting pool serum neutralization tests carried out in microtiter plates (Lim-Benyesh-Melnick antisera pools).

Results

Of the 23 samples collected, 5 were shown to contain virus: 1 sample at Dallas, 3 samples at Pomona, and 1 sample at Blue Plains. The experimental details and results are presented in Table 28.

The Blue Plains sample is labeled "unusual" due to the exceptionally high number (153) of virus plaques isolated; this high virus concentration finding could not be duplicated during subsequent or prior runs at the Blue Plains site. Operational reports from the Blue Plains plant show that there was an unusually high total bacteriological plate count on May 30, 1975. A total plate count of 1600 organisms per 100 ml was measured in samples collected and analyzed by Blue Plains personnel on this date.

The three virus-containing samples obtained at the Pomona site were not virus typed (although each was positively shown to contain virus). Six virus plaques were isolated at sample site 4A (System 2, chlorination followed by carbon adsorption), and one virus plaque was isolated at sample site 3A (System 1, chlorination).

The active sample collected at the Dallas site was shown to contain two plaque-forming units, each identified as polio virus 1. Recovery of polio virus 1 from a natural source is not surprising, since other field studies of a number of polluted bodies of water have shown polio virus to be the most common enterovirus encountered (approximately 60% of the time).

COLLECTION AND SHIPMENT OF EFFLUENT SAMPLES

The wastewater treatment facilities monitored in this study included three pilot plants and two full-sized plants. Each was visited by GSRI personnel to coordinate sample collection and shipping. Site personnel were

TABLE 28. EXPERIMENTAL RESULTS FOR VIRAL SAMPLING

Date	Location	Type Water Sampled	Enteric Viruses, PFU BGM	Enteric Viruses, PFU PMK	Remarks
9/13/74	Dallas	Final Effluent	0	0	
12/10/74			0	2	Identified as Polio I
12/11/74			0		
11/11/74	Pomona	4A System 2 Cl + C	0	1	Ident. not avail.
11/11/74		3A System 1 Cl	0	0	
11/12/74		4A System 2 Cl + C	0	5	Ident. not avail.
11/12/74		3A System 1 Cl	0	1	Ident. not avail.
11/04/75		3B System 3 O_3	0	0	Run A: Morning
11/04/75		3B System 3 O_3	0	0	Run B: Afternoon
11/05/75		4A System 2 Cl + C	0	0	Run A: Morning
11/05/75		4A System 2 Cl + C	0	0	Run B: Afternoon
11/06/75		3B System 3 O_3	0	0	Run A: Morning
11/06/75		3A System 1 Cl	0	0	Run B: Afternoon
11/07/75		4A System 2 Cl + C	0	0	Run A
8/16/74	Tahoe	Final Effluent	4	0	
8/16/74		Luther Pass	0	0	
11/16/74			0	0	
9/11/74	Blue Plains	Final Effluent	0	0	System 1
4/15/75			0	0	System 2
4/16/75			0	0	"
5/30/75			89	64	Unusual: Total Bacteria Plate Count 1600 organisms/100 ml.
9/09/75			0	0	
7/08/75	Escondido	Final Effluent	0	0	

requested to provide operating data such as flow diagrams, daily flow measurements, and other routinely assembled information. Data were also requested for specific parameters that had to be measured immediately after sampling.

Sampling procedures and tentative schedules were sent to the appropriate personnel following the site inspections. Scheduling changes were required at all sites during the course of the program.

Miniature Carbon Adsorption Method (CAM) samplers were shipped to the AWT plants in Dallas, Pomona, Blue Plains, Escondido, and South Lake Tahoe in August 1974. Instructions for assembling and operating the CAM samplers were sent with each unit. The Orange County, California, facility was not expected to be operational until January 1975.

GSRI prepared the sample containers prior to shipment to the AWT plants. The containers were washed, and the proper preservatives were added (2). Labels included the preservative and the concentration of preservative following addition of the water sample. On each label were spaces designated for date and time of sampling and sample number; this information was to be added by the sampling personnel. A typical sample set required three styrofoam shipping cartons and the following containers: 11 plastic one-liter bottles, 6 glass one-liter bottles, 1 four-ounce sterile bottle, 1 35-ml bottle, 1 mini-CAM sample column, and 6 packages of reusable ice substitute.

The CAM sample column contained 70 grams of activated carbon (Filtrasorb 200). All glass containers were securely packed with foam rubber to prevent breakage and were shipped via air freight to the AWT plants.

Sample collection was accomplished in 48 hours if no difficulties were encountered. The mini-CAM sampler was started 24 hours prior to initiation of the 24-hour composite sample collection since a 48-hour, controlled flow rate sampling is required. The 35-ml container was filled in three additions throughout the 24-hour sampling period and was shipped to the EPA laboratories in Cincinnati, Ohio. The bacterial sample was collected as a grab sample at the end of the 24-hour sampling period. The remaining samples were taken from the 24-hour composite samples routinely collected by site personnel as part of their on-going operations. An 18.9-liter grab sample was taken in lieu of a composite sample when samples were collected simultaneously for viral and organic concentrates.

Following collection of samples, the cartons were repacked and shipped to GSRI-New Orleans via air freight. Upon their arrival in New Orleans, La., pesticide samples were repackaged and immediately shipped by bus to the New Iberia, Louisiana laboratories for analysis. The bacteriological sample was shipped to a subcontracting laboratory in Hattiesburg, Mississippi. Transit times varied from a few hours for the shipment of pesticide samples from New Orleans to New Iberia to 1-13 days for air freight shipments. The samples from the AWT plant at Lake Tahoe were in transit the longest since these samples had to be trucked to an air freight office.

A variety of difficulties encountered by the AWT plants necessitated some schedule revisions for sample collections. Minimal schedule revision was needed at the Dallas and Lake Tahoe facilities. The AWT plant at Blue Plains was closed for an 8-month period following collection of the first three samples; however, sampling proceeded regularly when the plant was reopened. Most scheduling difficulties were reported from the Pomona AWT plant, where three different treatment processes were being evaluated. The three processes, each operated for a 24-hour period, differed in the final treatment of the effluent. Flexible scheduling was required so that representative samples could be obtained for each of the three processes. The Orange County AWT plant, scheduled to be operational in January 1975, suffered several major delays. The sampling was not completed until March 12, 1976, and a mini-CAM sampler was not provided.

ANALYTICAL PROCEDURES FOR EFFLUENT CHARACTERIZATION

The analytical procedures used to quantify the constituents in the effluent of the AWT plants were selected from two sources:

1. Manual of Methods for Chemical Analysis of Water and Wastes (2).
2. Standard Methods for the Examination of Water and Wastewater, 13th Edition (1).

These sources will be referred to as the EPA Manual and Standard Methods, respectively, in the following discussion. Quality assurance of the data was provided by following the guidelines in the Handbook for Analytical Quality Control in Water and Wastewater Laboratories (3).

Parameters investigated are listed in Table 29. The information regarding storage requirements and preservatives for stabilizing the samples was obtained from the EPA Manual. The majority of the analyses required cooling to 4°C and collection and storage in plastic or glass containers. Selected parameters requiring additional preservatives are listed in Table 30. The minimum detection limits for each parameter are presented in Table 31. A brief description of the method used, special quality control measures required, and instrumentation employed for each parameter monitored in the present is presented below.

Organic Constituents

Total Organic Carbon (TOC)--

Organic carbon in the samples was converted to carbon dioxide (CO_2) by catalytic combustion. The CO_2 was measured directly by infrared detection. The amount of CO_2 is directly proportional to the concentration of carbonaceous material in the sample. Instrumentation included Beckman 915 and 915A Carbon Analyzers. Quality control samples analyzed as unknowns included two samples provided by EPA containing low (4 mg/l) and high level TOC (145 mg/l).

Chemical Oxygen Demand (COD)--

The COD method determines the quantity of oxygen required to oxidize organic matter in a water sample under specific conditions of oxidizing agent, temperature, and time. Organic substances in the sample are oxidized

TABLE 29. ANALYTICAL PARAMETERS USED TO CHARACTERIZE EFFLUENT SAMPLES

Physical
- Color
- Conductivity
- Foaming
- Odor
- Taste
- Temperature
- Turbidity
- Residue
- Dissolved Solids (TDS)
- Suspended Solids

Anions
- Sulfate (SO_4)
- Chloride (Cl)
- Fluoride (F)
- Nitrate (NO_3)
- Nitrite (NO_2)
- Cyanide (CN)

Metals
- Sodium (Na), Arsenic (As), Boron (B), Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Lead (Pb) Manganese (Mn), Mercury (Hg), Selenium (Se), Silver (Ag), Zinc (Zn), Barium (Ba)

Radiation
- Gross Beta
- Gross Alpha
- Tritium

General
- Total Kjeldahl Nitrogen (TKN)
- Ammonia (NH_3)
- Alkalinity
- Calcium Carbonate Stability
- Chlorine Demand
- pH
- Ultraviolet Scan

Organic
- Total Organic Carbon (TOC)
- Chemical Oxygen Demand (COD)
- Phenol
- Carbon Alcohol Extraction (CAE)
- Carbon Chloroform Extraction (CCE)
- Pesticides:
  - Aldrin, Dieldrin, Endrin, Heptachlor, Lindane, DDT.
  - Chlorodane, Methoxychlor, 2,4-D, 2,4,5-TP (Silvex), 2,4,5-T
  - Diazinon
  - Ethyl Parathion, Imidan, Methyl Azinphos
  - Methyl Parathion, Carbaryl, Fluomenturon, Carbofuran

Biological
- Coliform, Total
- Coliform, Fecal
- Standard Plate Count
- Virus
  - Coxsacki
  - Polio
  - Adenovirus
  - Echo
  - REO
- Salmonella

TABLE 30. PRESERVATION METHODS RECOMMENDED FOR SELECTED PARAMETERS

Parameters	Preservative
Metals	HNO_3 to pH < 2
COD	H_2SO_4 to pH < 2
Cyanides	NaOH to pH 12
Ammonia	H_2SO_4 to pH < 2
TKN	H_2SO_4 to pH < 2
Nitrate	H_2SO_4 to pH < 2
TOC	H_2SO_4 to pH < 2
Phenol	H_3PO_4 to pH < 4, 1 g/l $CuSO_4$

TABLE 31. MINIMUM DETECTABLE LIMITS FOR ANALYTICAL PARAMETERS

Parameter	Units	Minimum Detectable Limit
Total Coliform	No./100 ml	1
Fecal Coliform	No./100 ml	1
Plate Count	No./ml	1
Salmonella	D/ND*	D/ND
Chloride	mg/1	0.1
Sulfate	mg/1	1
Alkalinity	mg/1 $CaCO_3$	0.1
$CaCO_3$ Stability	mg/1 $CaCO_3$	0.1
Dissolved Solids	mg/1	0.1
Nitrate	mg/1 N	0.05
Nitrite	mg/1 N	0.01
Ammonia	mg/1 N	0.01
Total Kjeldahl Nitrogen	mg/1	0.01
Sodium	mg/1	0.1
Arsenic	μg/1	10
Barium	μg/1	25
Boron	μg/1	500
Cadmium	μg/1	1
Chromium	μg/1	1
Copper	μg/1	1
Fluoride	mg/1	0.1
Iron	μg/1	1
Lead	μg/1	1
Manganese	μg/1	1
Mercury	μg/1	0.3
Selenium	μg/1	25
Silver	μg/1	1
Zinc	μg/1	1
COD	mg/1	5
TOC	mg/1	1

*D/ND = Detected/Not Detected

(continued)

TABLE 31 (continued)

Parameter	Units	Minimum Detectable Limit
CCE	mg/1	0.01
CAE	mg/1	0.01
Chlorine Demand	Determined on site	
Residual Chlorine	Determined on site	
Cyanide	mg/1	0.005
Phenols	μg/1	1
Aldrin	μg/1	0.005
Dieldrin	μg/1	0.009
Endrin	μg/1	0.014
Heptachlor	μg/1	0.006
Lindane	μg/1	0.004
DDT	μg/1	0.0016
Chlorodane	μg/1	0.017
Methoxychlor	μg/1	0.046
2,4-D	μg/1	0.023
2,4,5-TP	μg/1	0.016
2,4,5-T	μg/1	0.011
Diazinon	μg/1	0.011
Ethyl Parathion	μg/1	0.012
Imidan	μg/1	0.078
Malathion	μg/1	0.015
Methyl Azinphos	μg/1	0.108
Methyl Parathion	μg/1	0.018
Carbaryl	μg/1	0.180
Fluometuron	μg/1	0.065
Carbofuran	μg/1	0.125

by potassium dichromate in 50% sulfuric acid at reflux temperature. The excess dichromate is titrated with standard ferrous ammonium sulfate using orthophenanthroline ferrous complex as an indicator. The EPA Manual gives both a low level and a high level method for COD determinations, while only a general method is presented in Standard Methods. The low level method is applicable for samples having a COD in the range of 5-50 mg/l. The high level technique is used for saline water samples (<1000 mg/l Cl^-) to counteract the positive interference due to quantitative oxidation of chloride by dichromate. The chloride interference is removed by addition of mercuric sulfate, which serves as an efficient complexing agent for chloride. The high level COD procedure was used for the samples received early in the study. Since the COD levels measured were in the 5-50 mg/l range, the low level method was used for the remainder of the study.

Quality control samples were analyzed using both the high and low level methods. Two standard samples containing 10.3 mg/l and 370 mg/l COD were provided by EPA. In-house standards were prepared from potassium acid phthalate to be analyzed as unknowns with each sample set. The high level standard contained 500 mg/l COD, and the low level standard contained from 10-20 mg/l COD.

Phenol--

The concentration of phenolic compounds was determined by a colorimetric procedure at a controlled pH of 10. Phenolic materials react with 4-aminoantipyrine (4-AAP) in the presence of potassium ferricyanide to form a stable reddish-brown dye. The amount of color produced, measured at 500 nm, is a function of the concentration of phenolic material. The color response with 4-AAP is not the same for all phenolic compounds; therefore, phenol has been selected as a standard, and color produced by the reaction of other phenolic compounds is represented as phenol (2). An in-house quality control standard was analyzed as an unknown with each set of effluent samples.

Carbon Chloroform Extraction (CCE)--

CCE represents a mixture of organic compounds that can be adsorbed on activated carbon under prescribed conditions and subsequently desorbed with the solvent chloroform (7). The carbon from the mini-CAM sampler is dried at 40°C for 24-72 hours and transferred to a soxhlet extraction thimble. Extraction is performed with 300 ml of chloroform for 44 hours using a 6 minute extraction cycle. The excess chloroform is distilled until the volume remaining is less than 20 ml. The content is transferred to a tared vial and evaporated to dryness using a gentle stream of dry, oil-free air. The vial is further dried in a desiccator until constant weight has been achieved. This method is primarily for monitoring the general organic content of waters and is not designed as a collector of organics for further identification.

Carbon Alcohol Extraction (CAE)--

CAE represents a mixture of organic compounds that can be adsorbed on activated carbon and desorbed with the solvent 95% ethyl alcohol after the chloroform-soluble organics (CCE) have been desorbed under prescribed conditions (7). The extraction time for CAE is 48 hours, using an initial extraction time of 6.5 min/cycle, for a total of 410-480 cycles. The volume of alcohol and volume reduction procedures are identical to those cited above for CCE.

Pesticides--

The large-scale use of pesticides has contributed to the presence of the parent compounds and their metabolites in surface and ground waters and ultimately in water supplies (6). The levels of pesticides and their metabolites in the effluent samples were analyzed using gas chromatographic (GC) techniques. The effluent samples were subjected to pretreatment, extraction, and cleanup techniques, and the extracts were injected into Micro-Tek 220 gas-liquid chromatographs equipped with suitable columns and electron capture and flame photometric detectors.

The organochlorine pesticides analyzed for included aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, lindane, and methoxychlor. The sample pretreatment procedure included extraction of 1700 ml of sample with 200 ml of hexane (6,8). The hexane phase was passed through a funnel filled with anhydrous sodium-sulfate and was collected in a round bottom flask. The solvent volume was reduced to 25 ml with a Snyder column and further reduced by vacuum to 2 ml. The sample was transferred to a 10 ml volumetric flask and diluted to volume with hexane. The gas chromatographic analyses were performed using a GC instrument equipped with an electron capture detector and a 3% OV-1 column. Confirmation of the compounds detected in the extracts was performed on a 5% QF-1 column.

Organophosphate pesticides examined included diazinon, ethyl parathion, imidan, malathion, methyl azinphos, and methyl parathion. The extracts from the organochlorine procedure were analyzed on a GC instrument equipped with a flame photometric detector and a 10% DC-200 column.

Three phenoxy herbicides were analyzed for in the water samples from the AWT plants (9). These included 2,4-D; 2,4,5-TP (silvex), and 2,4,5-T. The water samples (1700 ml) were extracted twice with 100 ml of 1:1:1 ethanol: chloroform:diethyl ether following pH adjustment to 2 with concentrated sulfuric acid. The extracts were drained through funnels filled with sodium sulfate and collected in 300 ml round bottom flasks. The sodium sulfate funnels and separatory funnels were washed with aliquots of hexane (80 ml), and the volume of organic solvent was reduced to less than 20 ml using a vacuum water bath. The samples were evaporated to dryness in a test tube under a gentle stream of nitrogen. The addition of 2 ml of n-butanol and 6 drops of concentrated sulfuric acid to the tubes was followed by heating in a constant temperature bath (95°-100°C) for 30 minutes. The test tubes were placed in an ice bath for 15 minutes and extracted with 20 ml of hexane and two 5-ml aliquots of isooctane. The organic phases were transferred to 10-ml volumetric flasks and sodium sulfate was added to dry the samples. The prepared samples were analyzed by gas chromatography using an electron capture detector and a 3% OV-1 column. Confirmation of the detected compounds was performed on a 5% QF-1 column.

Carbaryl, carbofuran, and fluometuron contents of the carbamate classification were determined for this study. The extraction method for isolation of these carbamates required 1700 ml of effluent (10). Two 200 ml benzene extractions were performed; the extracts were passed through a funnel containing sodium sulfate and were collected in a 500 ml round bottom flask. The sodium sulfate funnels were washed with three 20-ml aliquots of benzene. The solvent volume was reduced to approximately 2 ml in a 45°C water bath under vacuum and was transferred to a 10-ml volumetric flask. The samples were diluted to 10 ml with benzene and injected into a GC instrument equipped with an electron capture detector and a 10% DC-200 column.

Rigorous quality control measures were followed throughout the program. Analytical Reference Standards of each compound of interest were obtained from the EPA, Health Effects Research Laboratory, Research Triangle Park, and were used to prepare analytical standards and spiking solutions. Deionized water samples spiked with the test compounds were analyzed with each batch of test samples to determine the percent recovery of each compound. In addition, glassware blanks and reagent blanks were included with each set of samples to verify the absence of interfering substances. Because the limited sample size prevented the analysis of duplicate samples, duplicate spiked deionized water samples were analyzed.

Anion Parameters

Chloride--

Chloride ion can be titrated with mercuric nitrate to form soluble, slightly dissociated mercuric chloride. Diphenylcarbazone indicates the end point of the titration in the pH range from 2.3-2.8 by formation of a purple complex at the first appearance of excess mercuric ions. Since the applicable pH range is limited, a mixture of nitric acid and diphenylcarbazone is added to adjust the pH to 2.5 ± 0.1. Xylene cyanol FF is added to the mixture to serve as a pH indicator to provide background color for improved end-point detection.

Each set of effluent samples analyzed for chloride content included a quality control sample. The in-house quality assurance standard analyzed as an unknown with each determination contained 80 mg/l chloride.

Sulfate--

A turbidimetric method suitable for the analysis of sulfate at all concentration ranges was employed for the AWT plant effluents. The water sample, combined with a reagent composed of glycerol, hydrochloride, and alcohol, is placed on a magnetic stirrer. Barium chloride is added to the solution while stirring is maintained at a constant rate. Immediately following a one-minute stirring period, an aliquot is poured into an absorption cell and the turbidity is measured at 30-second intervals for 4 minutes or until a constant measurement is obtained. In general, maximum turbidity occurred within 2 minutes. A Spectronic 20 UV-Visible spectrophotometer using a wavelength of 420 nm was employed for this determination.

In addition to calibration standards prepared from 0.0200 N H_2SO_4, a quality control sample was included with each sample set. The in-house standard employed for this purpose contained 90 mg/l sulfate.

Fluoride--

A fluoride concentration of 1 mg/l is an effective preventive for dental cavities and does not have harmful effects on health (9). Fluoride content may be determined potentiometrically using a selective ion fluoride electrode in conjunction with a standard single-junction reference electrode and a pH meter having an expanded millivolt scale. The fluoride electrode consists of a lanthanum fluoride crystal across which a potential is developed by fluoride ions. The method is accurate at pH values from 5 to 9.

Quality control was provided for fluoride analysis by analyzing a 1 mg/l standard with each analytical determination. This standard was analyzed as an unknown sample and was not part of the set of calibration standards containing 0(blank), 1, 2, 3, 4, 5, 6, 8, and 10 mg/l fluoride.

Cyanide--

The cyanide concentration of the AWT effluent samples was measured using a colorimetric procedure. Cyanide is defined as cyanide ion and complex cyanides converted to hydrocyanic acid (HCN) by reaction in a reflux system of a mineral acid in the presence of cuprous ions. The colorimetric method requires conversion of cyanide to cyanogen chloride by reaction with Chloramine-T ($pH<8$). Color is formed by the addition of pyridine-pyrazolone reagent and the absorbance is read at 620 nm.

General Analytical Parameters

Nitrogen, Nitrate-Nitrite--

The cadmium reduction method recommended by the EPA manual was used for the analysis of nitrate and nitrite expressed as mg/l nitrogen. The procedure is based on the reduction of nitrate to nitrite by granulated copper-cadmium. If suspended matter is allowed to pass through the column, the sample flow will be restricted; filtration through a glass fiber filter or 0.45 μ membrane filter is recommended for samples containing high concentrations of suspended matter.

The nitrite content of the sample is determined by diazotizing with sulfanilamide and coupling with N-(1-naphthyl)-ethylenediamine dihydrochloride to form a highly colored azo dye. The absorbance of the azo dye is measured with a Spectronic 20 spectrophotometer at a wavelength of 540 nm with a 1 cm cell.

The nitrate concentration is measured by difference by converting all nitrate to nitrite and subtracting the quantity of nitrite determined as described previously. Conversion of nitrate to nitrite is accomplished by passing a filtered sample through the copper-cadmium reduction column. The reduction column is prepared by cleaning cadmium granules with dilute HCl and adding a 2% solution of copper sulfate to the granules until the color partially fades. Completion of the copperizing is indicated by the formation of a brown, colloidal copper precipitate.

Nitrogen, Ammonia--

Ammonia was determined potentiometrically using a selective ion ammonia electrode and a pH meter having an expanded millivolt scale. The ammonia electrode uses a hydrophobic gas-permeable membrane to separate the sample solution from an ammonium chloride internal solution. Diffusion of the ammonia alters the pH of the internal solution; this alteration is sensed by the pH electrode. The constant level of chloride in the internal solution is sensed by a chloride selective ion electrode which acts as the reference electrode. Special precautions were taken to insure that the distilled water was free of ammonia. A 10 mg/l standard was analyzed for NH_3-N with each set of samples for quality control purposes.

Total Kjeldahl Nitrogen (TKN)--

Total Kjeldahl nitrogen includes ammonia and organic nitrogen but does not include nitrogen in either nitrate or nitrite form. The TKN is converted to ammonium sulfate by heating the sample in the presence of concentrated H_2SO_4, K_2SO_4, and $HgSO_4$ until SO_3 fumes appear. The colorless or pale yellow solution is cooled, diluted to the appropriate volume and made alkaline with hydroxide-thiosulfate. Following distillation of the ammonia, detection may be accomplished by Nesslerization titrimetry, or potentiometrically. The detection method used for this study was the potentiometric selective ion electrode technique described above. An in-house quality control standard containing 50 ppm TKN was included as an unknown with each set of samples.

Alkalinity--

Alkalinity determinations provide a quantitative measure of the ability of a water sample to neutralize strong acids to an arbitrarily designated pH. Results are expressed as mg/l calcium carbonate ($CaCO_3$) representing the alkalinity equivalent to the resultant amount of $CaCO_3$. Sample pretreatment such as titration, dilution, or concentration must be avoided. An unaltered effluent sample is titrated to an end point of 4.5. The potentiometric method was employed for this study since its use precludes several interferences, such as residual chlorine, color, and turbidity inherent with indicator techniques. An in-house quality control standard containing 300 mg/l alkalinity (as $CaCO_3$) was analyzed with each set of samples as an unknown sample.

Calcium Carbonate Stability--

The analysis for $CaCO_3$ stability is performed with a portion of the sample used for the alkalinity measurement (11). An aliquot of the sample is transferred to a BOD bottle, and 0.3-0.4 grams of $CaCO_3$ are added. The bottle is completely filled and shaken at 10-15 minute intervals for 3 hours. The powdered $CaCO_3$ is allowed to settle to the bottom by frequently tapping the BOD bottle. The bottle is then left untouched for a 24-hour period. A portion of the supernatant is transferred from the bottle by pipet and filtered; the first 25 ml is discarded. The alkalinity is determined using this sample; the difference between this determination and the first alkalinity measurement is recorded as calcium carbonate stability. A positive number is obtained if the second value is higher while a negative value indicates that the second alkalinity measurement is less than the first. Water samples yielding positive $CaCO_3$ stabilities are undersaturated with respect to $CaCO_3$ and are corrosive. Soda ash, lime, calcium hydroxide, calcium oxide, or sodium carbonate may be added to correct corrosive conditions. Water samples with negative $CaCO_3$ stabilities are supersaturated and may cause scaling which can be minimized by the addition of phosphates or alum.

Residual Chlorine--

The analysis of AWT effluent samples for residual chlorine was performed at the sampling site. Chlorine determinations must be started immediately after sampling, avoiding excessive light and agitation.

Chlorine Demand--

The chlorine demand of a water sample is caused by inorganic reductants such as ferrous, nitrite, manganous, sulfide, and sulfite ions. Chlorine demand determinations established the amount of chlorine that must be applied to water to produce a specific free, combined, or total available chlorine residual after a selected period of contact. The measurement of clorine demand was performed at the AWT plant sites since the determination of this parameter is required prior to chlorination.

Trace Metals--

Several analytical techniques were used for trace metal determinations; however, the majority of the metals of interest were analyzed using atomic absorption spectrophotometry (AAS). Sample pretreatment was required for most analyses. Atomic emmission spectrophotometry (AES) was used for sodium analyses due to the increased sensitivity of emission for this metal. Both techniques involve aspiration of the sample into the flame where atomization occurs. AES measures the amount of light emitted at a given wavelength. AAS measures the amount of light absorbed from a hollow cathode lamp source by the sample in atomic form. Generally, AAS is the more sensitive of the two techniques since the ratio of unexcited to excited atoms is very high. The instrumental parameters such as wavelength, flame system, and slit width are summarized in Table 32 for those metals analyzed by AAS or for AES.

TABLE 32. INSTRUMENTAL PARAMETERS FOR AAS/AES DETERMINATIONS

Metal	Analytical Wavelength (nm)	Slit Width (nm)	Flame System
Barium	553.6	0.2	$N_2O - C_2H_2$
Boron	249.7	0.7	$N_2O - C_2H_2$
Cadmium	228.8	0.7	Air - C_2H_2
Chromium	357.9	0.7	Air - C_2H_2
Copper	324.7	0.7	Air - C_2H_2
Iron	248.3	0.2	Air - C_2H_2
Lead	283.3	0.7	Air - C_2H_2
Manganese	279.5	0.7	Air - C_2H_2
Mercury	253.7	0.7	Flameless
Selenium	196.0	2.0	Air - C_2H_2
Silver	328.1	0.7	Flameless
Sodium	589.6	0.2	Air - C_2H_2
Zinc	213.9	0.7	Air - C_2H_2

Sodium determinations were made using the effluent sample in the form received since relatively high sodium levels in the mg/l range were measured. Arsenic analyses were performed using the silver diethyldithiocarbamate technique. Inorganic arsenic was reduced by zinc in acid solution to arsine, AsH_3. The arsine was passed through a scrubber containing glass wool impregnated with lead acetate solution and into an absorber tube containing silver diethyldithiocarbamate dissolved in pyridine. The arsenic reacts with the silver salt to form a soluble red complex suitable for photometric measurement at 535 nm.

Mercury content was determined using flameless cold vapor atomic absorption. The mercury is reduced to the elemental state and aerated from solution in a closed system. The mercury vapor passes through a cell positioned in the light path of an atomic absorption spectrophotometer.

Silver content was measured using the untreated effluent samples and the graphite furnace flameless atomic absorption. Preconcentration of the sample was not required using this technique. Since hydrochloric acid is used to dissolve the residue during preconcentration, the formation of insoluble silver chloride precludes silver analysis in this manner.

The remainder of the trace metals analyzed for this study, barium, boron, cadmium, chromium, copper, iron, lead, manganese, selenium, and zinc, were determined from concentrated effluent samples. A volume of 1500 ml of water, acidified to pH 2 with nitric acid is placed in a large beaker and more HNO_3 (50 ml) is added. The solution is evaporated to dryness, making certain that the sample does not boil. The system is cooled, HNO_3 is added, and the temperature is increased until a gentle reflux action occurs. Digestion is complete when a light residue is noted. The residue was dissolved in 1:1 HCl, and the sample is filtered and diluted to 50 ml. The possibility of contamination of reagents or glassware with low level metal concentration was discounted by concentrating a distilled deionized water sample in like manner concurrently with each set of samples. The accuracy of the data was examined with each analysis set by concentrating standard reference samples for trace metals and performing the AAS analyses. Instrumentation employed included a Perkin-Elmer 303 AAS equipped with a HGA 2000 graphite furnace and a Perkin-Elmer 306 AAS equipped with a HGA 2100 graphite furnace.

Physical Parameters

Odor--

Odor is recognized as a factor affecting water quality in several ways including acceptability for preparation of food and tainting of fish. Most organic and inorganic chemicals contribute odor to water samples. Odor tests may not be performed chemically; most odors are too complex to permit definition by isolation and identification of odor-producing chemicals. Odor tests are performed using human judgment to arrive at qualitative descriptions and approximate quantitative measurements of odor intensity. The effluent sample is diluted with odor-free water until a dilution is found that is at least perceptible to each tester. Panels of from 5-10 persons are recommended since any one person will not be consistent in the concentrations detectable from day to day. The tester must be free from colds and allergies and, preferably, should be a nonsmoker. Two or more blanks (odor-free water) near the expected threshold are included with each set of samples to be tested. Observations of each tester are recorded throughout the test and a threshold number is determined.

Taste--

Taste and odor differ in the nature and location of the receptor nerve sites. The tongue is the primary receptor for taste, while odor is detected high in the nasal cavity. There are only four true taste sensations: sour, sweet, salty, and bitter. Concentrations of inorganic salts producing taste may range from a few tenths to several hundred milligrams per liter. The complex sensation experienced in the mouth during the act of tasting is a combination of taste, odor, temperature, and feel collectively called flavor. The absence of taste is not to be considered desirable; distilled water is less pleasant to drink than certain high-quality waters.

The same dilution system as that described for odor is employed for taste testing. A series of samples including blanks is tested by each panel member. Both taste and aftertaste are recorded for each taster. The individual threshold and the threshold of the panel are determined. Taste tests were not performed for the effluent samples from Orange County since a viral study was in progress at this facility. Taste tests were excluded for the other AWT samples where high total plate counts were observed or if any fecal coliforms were detected.

Turbidity--

Turbidity in water is caused by the presence of suspended matter such as clay, silt, finely divided organic and inorganic matter, plankton, and other microscopic organisms. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample. What has been the standard method for the determination of turbidity is based on the Jackson candle turbidimeter, however, the lowest value that can be measured directly in this instrument is 25 units (13). Turbidities of treated water generally are 0-5 units, therefore, indirect secondary methods are required. The first two samples in the program were analyzed for turbidity as expressed in units of mg/l SiO_2. Later investigations were performed with a procedure recommended by Standard Methods and the EPA Manual using formazin as the turbidity standard. The data were reported in Jackson Turbidity Units (JTU) or Nephelometric Turbidity Units (NTU) which are considered comparable (4). A Hach Turbidimeter was employed for this study (NTU).

Color--

Color in water may result from the presence of natural metallic ions (iron and manganese), humus and peat materials, plankton, weeds and industrial wastes. The term color, as applied to these studies, is the color of the water from which the turbidity has been removed. Color is determined by visual comparison of the effluent samples with known concentrations of colored solutions. The standard employed was platinum-cobalt where one unit of color is that produced by 1 mg/l Pt in the form of the chloroplatinate ion. The color of the water increases as the pH increases.

Conductivity--

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This number is dependent on the total concentration of the ionized substances dissolved in the water and the temperature at which the measurement is made. The specific conductance is reported in units of micromhos and is measured directly with an instrument consisting of a source of alternating current, a Wheatstone bridge, a null indicator, and a conductivity cell. The cell is rinsed with one or more portions of the sample to be tested, and the measured specific conductance and temperature are recorded.

Residue, Suspended and Dissolved--

The total residue in an effluent sample is determined by transferring a well-mixed aliquot of the sample to a tared evaporating dish and evaporating to dryness at 103-105°C. Total filterable solids are defined as those solids which pass through a standard glass fiber filter and dry to constant weight at 180°C. Glass fiber filter discs suitable for this study include Reeve Angel Type 934-A and 984-H, Gelman Type A and are either 4.7 cm or 2.2 cm in diameter. Nonfilterable solids are defined as those solids which are retained on the glass fiber filter and are dried to constant weight at 103-105°C.

Foaming--

In lieu of a published technique, a method was devised to measure the foaming capacity of the effluent samples. A 30-ml aliquot of sample was vigorously shaken for exactly 30 seconds. A stopwatch was triggered with the last stroke of the shaking sequence, and the time required for the last bubble to disappear was recorded.

Radiological Parameters

The radiological parameters determined for this study included gross alpha, gross beta, and tritium.

Radioactivity in water arises from both natural and artificial sources. Primary natural sources are the decay series and cosmic radiation. Background radioactivity usually contributes less than picocurie per liter quantities of alpha and tens of picocuries per liter quantities of beta activity. Distribution of tritium is fairly uniform; the activity is most abundant in rain water and least abundant in aged water due to the physical decay to helium. There are artificial sources, such as residual fallout from weapons testing, particle accelerators, reactors, and fusion research.

For these parameters, the amount to be sampled is governed by the residue concentration. From the concentration and the planchet area the milligrams per square centimeter value is calculated, and a volume which gives less than 10 milligrams per square centimeter is used. The exact amount of solids is determined using tared planchets. The process of evaporation is carried out on a hot plate in beakers. Methyl orange is used as an indicator, and the sample is brought to a pH of 5 with nitric or hydrochloric acid. When evaporation is almost complete, the residue is transferred to a tared planchet and drying is completed in an oven at 103-105°C. The samples are stored in desiccators while waiting to be counted.

An internal proportional counter is used; for gross alpha the voltage is set to the alpha plateau, and for gross beta the voltage is raised to reach the beta plateau. The efficiency used in calculating the activity concentration is determined by measuring the count rate at varying densities of standard, thereby correcting for self-absorption. Calculation of the counting error is based on sample count rate and background count rate. Both the activity and the counting error are expressed as activity per liter. This method is published in Standard Methods.

The procedure for tritium employs a scintillation solution which is prepared from spectroquality dioxane, PPO(2,5,diphenyloxazole), POPOP[1,4-di-2-(5-phenyloxazolyl)benzene], and naphthalene, and which is stored in the dark. The sample is distilled to near dryness to remove nonvolatile radioactive species and quenching agents. Four ml of each sample is mixed with 16 ml of reagent. The standard is prepared using 4 ml of solution of known tritium activity, plus 16 ml of scintillation reagent. The solution for background readings is prepared from tritium-free, distilled water in the same manner. All vials are dark-adapted for at least 3 hours before counting in an ambient temperature, liquid beta scintillation counter for a minimum of 250 minutes for the standard and samples, and from 500 to 6000 minutes (usually 1200) for the background. The counting efficiency is calculated from the standard, and the counting error is calculated from the sample and background count rates.

Bacteriological Parameters

Total Coliform--

Total coliform includes all aerobics and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C. The tube fermentation technique used for this analysis is divided into three phases: (1) the presumptive test, (2) the confirming test, and (3) the completed test.

For the presumptive test a series of fermentation tubes containing lactose broth are inoculated with appropriate graduated quantities of sample, and incubated at 35°C for approximately 24 hours. After 24 hours the tubes are checked for gas formation. If no gas formation is evident the tubes are returned to the incubator to complete the 48-hour incubation.

For the confirming test the positive tubes and tubes which were dilutions of the same sample are shaken gently. Using a sterile transfer loop, 1 to 3 loops of each tube are transferred to a tube containing green lactose bile broth and are incubated at 35°C for 48 hours. All positive tubes are plated out on eosin methylene blue agar plates. The plates are incubated at 35°C for 24 hours. The resulting colonies are classified as "typical" (nucleated, with or without a metallic sheen), "atypical" (opaque, unnucleated, mucoid, pink after 24 hour incubation), or "negative" (all others).

The completed test follows the confirming test and consists of the transfer of one or more typical or atypical colonies from the eosin methylene blue plates to a lactose broth fermentation tube and to a nutrient agar slant. Both the fermentation tubes and agar slants are incubated at 35°C for 24 to 48 hours. If gas production is observed after 24 or 48 hours, but no spores are noted, the colonies from the agar slant tube (which were plated with the same colony as the lactose tube in question) are gram-stained and examined microscopically for the presence of gram-negative rods. Positive tubes show gas production, no spores, and gram-negative rods.

Fecal Coliform--

The procedure for fecal coliform distinguishes between organisms from the intestines of warm blooded animals and those from other origins. With the aid of a sterile transfer loop, a small amount of sample from each positive, mixed, lactose bile broth tube is transferred to EC medium and incubated at 44.5°C for 24 hours. Gas production in EC medium is accepted as confirmation of fecal coliform. Fecal and total coliform results are given as most probable number (MPN) from the MPN Index, according to the number of positive tubes of each dilution.

Salmonella--

The procedures used for isolation and identification of salmonella were obtained from the Bacteriological Analytical Manual (12) published by the Food and Drug Administration. The procedures include concentration, enrichment, selective growth, biochemical identifications, and serological techniques. Concentration was performed using membrane filter techniques. The membrane is sectioned and transferred to suitable enrichment media. Enrichment is accomplished with lactose broth and tetrathionate broth. The pathogens are separated by selective growth on brilliant green agar and on SS agar (salmonella-shigella). The samples are incubated 48 hours on these media. SS agar contains bile salt inhibitors, such as desoxycholate citrate and xylose lysine desoxycholate, which inhibit coliform growth. Brilliant green agar produces salmonella colonies which are pinkish white on a red background, although a few species of salmonella do not grow well. A few other organisms, proteous, citrobacter, and pseudomonas, occasionally produce pathogen resembling colonies. Colonies isolated as possible salmonella colonies are subjected to several biochemically selective media, such as decarboxylase, citrate, TSI, KCN broth, and raffinose broth. In the cases in which salmonella is still suspected at this point, agglutination studies are performed for final confirmation.

Investigation of Ultraviolet Region

As specified in the contract, an ultraviolet scan of each effluent sample was performed. The scan was recorded from 350 to 200 nm, which is the lowest effective range of quartz cuvettes. Instrument settings for the Varian Techtron Model 633 UV-visibile spectrophotometer are listed in Table 33.

The scans provide a measure of the quantities of organics present. As such, the analysis should give an indication of variation of total organics which absorb at above 200 nm.

TABLE 33. VARIAN INSTRUMENT SETTINGS

Chart Speed	2 centimeters/minute
Range	20 millivolts
Lamp	Ultraviolet
Scan Rate	30 millimicrons/minute
Mode	Absorbance
Zero Offset	Zero
Wavelength	350 - 200 nm
Slit Width	0.5 millimicrons

SECTION 5

RESULTS AND DISCUSSION

CHEMICAL ANALYSIS

Data Presentation

The number of effluent samples collected for chemical and biological analysis varied with each AWT plant. Nine effluent samples were analyzed for each of the three treatment systems at Pomona, California. The data for these three effluents are presented in Appendix A (Tables A-1, A-2, And A-3). Thirteen effluent samples were taken from the treatment system at Lake Tahoe, California (Table A-4). Eight samples were examined from the Dallas, Texas, facility (Table A-5). There were nine samples taken for analysis from the two treatment systems at the Blue Plains pilot plant in the District of Columbia; three were taken from System 1 which employed only physical-chemical procedures and six were taken from System 2 which combined both physical-chemical and biological processes. Data for Systems 1 and 2 are presented in Tables A-6 and A-7, respectively. Six effluent samples were collected from the AWT plant in Orange County, California (Table A-8), while only a single sample was examined from the Escondido, California, treatment system (Table A-9).

The data tables include the low, high, and average values, as well as standard deviations, σ, based on a stated number, η, of results. The parameters which were not present at sufficient levels for detection by the analytical techniques employed are designated as not detected, ND, in the data tables. The detection limits for each parameter are presented in Table 31. The units employed for each of the parameters are listed immediately after the specific parameter.

In the pesticide analyses, some data are presented as less than a given number, for example 2,4,5-T (<0.029), Pomona Process One, for Sample 6 (Table A-1). The analyst selected this method of reporting to indicate that the pesticide 2,4,5-T was detectable but at a concentration too dilute for accurate quantitative analysis. However, the indication of the presence of 2,4,5-T provides useful information for interpretation of the effectiveness of the treatment processes.

The reporting of data for carbaryl fluometuron and carbofuran is presented for the collective group, carbamates, since these pesticides were not found in any of the effluent samples.

Comparison of Treatment System Performance

The average values obtained for the various chemical, physical, biological, and radiological parameters for each of the treatment systems are presented in Tables 34 through 40. These data summaries permit comparisons between the removal efficiencies of each system.

The bacteriological data summarized in Table 37 show large differences between treatment systems. Data for individual samples were also significantly different as evidenced by the large standard deviation for total plate count. The reason is not clear. The number of samples taken was relatively small and improper handling and contamination from extraneous microorganisms may be responsible in some instances. Contamination of only one sample can significantly affect the statistical analyses.

The average zinc concentration is variable from plant to plant. In addition, both iron and zinc vary considerably from sample to sample for a given treatment process. The use of zinc and iron in pipes and the presence of industrial waste are possible reasons for the observed variations.

The turbidity results for the first two samples from Pomona Treatment Systems 1 and 2 shown in Appendix A, Tables A-1 and A-2 are presented in units of mg/l SiO_2 and may not be compared directly to future results in NTU.

The results of the organic analyses presented in Table 35 show a wide range of effluent qualities and may be dependent on the type of treatment system employed, particularly as it relates to the degree of exhaustion of the activated carbon processes. There does not appear to be a correlation between CCE and COD or TOC, and the ratio of COD/TOC suggests discrepancies in those measurements. For those reasons, it is difficult to correlate the type treatment with the organic quality of the effluent using the data.

The stoichiometric COD/TOC ratio of water is expected to approximate the molecular ratio of oxygen to carbon in CO_2 which is 2.66. Theoretically, the ratio limits may range from 0 when the organic material is resistant to oxidation by dichromate to 5.33 for methane or slightly higher if inorganic reducing agents are present (14). The COD/TOC ratios for the average values given in Table 35 are 0.9 (Tahoe), 2.55 (Blue Plains, 1), 1.35 (Blue Plains, 2), 1.28 (Pomona 1), 1.45 (Pomona 2), 1.52 (Pomona 3), 0.7 (Dallas), 1.62 (Orange County), and 0.28 (Escondido). The lack of agreement between theory and experiment for the COD/TOC ratios was noted early in the program. Attempts were made to determine if either of the two analytical methods was in error or if other contributions were altering the expected ratio. EPA provided GSRI with reference standards for BOD, COD, and TOC. The results of the analysis of these standards are presented in Table 40 and exhibit good agreement between experimental and true values. A low-level COD standard prepared in-house using potassium and phthalate was examined over a five-month interval from January to May 1975. The results of these analyses are given in Table 41. The early COD determinations were made using the high-level method; however, results indicated the low-level method would be appropriate for future determinations. Precision and accuracy data were not

TABLE 34. SUMMARY OF AVERAGES FOR SELECTED INORGANIC PARAMETERS ACCORDING TO TREATMENT SYSTEM

Inorganic Parameter	Tahoe	Blue Plains (1)	Blue Plains (2)	Pomona System 1	Pomona System 2	Pomona System 3	Dallas	Orange County
Chloride (mg/l)	65.3	188	66.1	87.9	107	98.6	73.1	222
Sulfate (mg/l)	28.1	70	49.0	77.1	85.6	89	92.1	309
Fluoride (mg/l)	0.24	1.23	0.75	0.67	0.79	0.73	1.34	0.74
Alkalinity as $CaCO_3$ (mg/l)	198	29.8	81.8	176	170	151	168	120
Calcium Carbonate Stability as $CaCO_3$ (mg/l)	3.58	40.3	3.95	0.58	0.50	1.94	15.8	4.05

TABLE 35. SUMMARY OF AVERAGES FOR ORGANIC PARAMETERS ACCORDING TO AWT PLANT

Organic Parameter	Tahoe	Blue Plains (1)	Blue Plains (2)	Pomona System 1	Pomona System 2	Pomona System 3	Dallas	Orange County	Escondido
CCE (mg/l)	0.8	1.3	0.07	1.2	0.5	0.8	0.4	0.2	--
CAE (mg/l)	2.3	1.3	2.0	3.3	2.9	3.0	2.8	1.4	--
COD (mg/l)	9.0	30.1	11.9	15.9	15.9	17.9	5.2	10.3	1.9
TOC (mg/l)	10.0	11.8	8.8	12.4	11.0	11.8	7.6	6.4	6.9

TABLE 36. SUMMARY OF AVERAGES OF PHYSICAL PARAMETERS ACCORDING TO AWT PLANT

Physical Parameter	Tahoe	Blue Plains (1)	Blue Plains (2)	Pomona System 1	Pomona System 2	Pomona System 3	Dallas	Orange County
Dissolved Solids (mg/l)	387	522	339	517	512	571	468	952
Conductivity (μ mhos)	669	855	527	828	890	937	761	1770
Turbidity (JTU)	1.57	--	1.00	0.89	0.66	1.15	0.37	1.06
Odor (No.)	2	--	25	5	2	6	14	9
Foaming (Sec.)	7.17	2.7	41.4	63.4	12.2	25.1	2.9	13.9

TABLE 37. SUMMARY OF BACTERIOLOGICAL PARAMETERS ACCORDING TO AWT PLANT

Bacteriological Parameter	Tahoe	Blue Plains (1)	Blue Plains (2)	Pomona System 1	Pomona System 2	Pomona System 3	Dallas	Orange County
Coliform (No/100 ml)	27.3	--	8	2.0	421	615	7.1	2.0
Fecal Coliform (No/100 ml)	1.3	460	ND	0.1	275	333	3.3	ND
Total Plate Count (10^5/100 ml)	3.5	8.5	3.2	0.2	7.6	140	0.018	0.424

TABLE 38. SUMMARY OF AVERAGE FOR TRACE METALS ACCORDING TO AWT PLANT

Trace Metal	Tahoe	Blue Plains (1)	Blue Plains (2)	Pomona System 1	Pomona System 2	Pomona System 3	Dallas	Orange County
Chromium (µg/1)	2.4	27	16	39	18.4	62	12	67
Copper (µg/1)	50.9	15	46	48	41	50	6	40
Iron (µg/1)	249	225	61	158	432	58	125	35
Lead (µg/1)	5	27	ND	6	ND	7	5	13
Manganese (µg/1)	12	15	7	14	8	7	5	3
Sodium (mg/1)	42.3	78.7	31	99.8	104	119	69.6	165
Zinc (µg/1)	1010	59	54	84	58	66	44	488

TABLE 39. SUMMARY OF AVERAGE FOR NITROGEN PARAMETER ACCORDING TO AWT PLANT

Nitrogen Form	Tahoe	Blue Plains (1)	Blue Plains (2)	Pomona System 1	Pomona System 2	Pomona System 3	Dallas	Orange County
Nitrate NO_3-N (mg/1)	1.7	ND	2.9	6.5	7.9	14.7	4.8	--
Nitrite NO_2-N (mg/1)	1.0	ND	ND	0.1	0.7	1.1	ND	ND
Ammonia-N (mg/1)	15.3	0.88	0.1	4.83	7.32	7.69	1.32	14.7
TKN (mg/1)	16.4	3.24	1.4	13.4	8.77	13.1	1.92	21.8

TABLE 40. ANALYSIS OF DEMAND STANDARD REFERENCE SAMPLES

Parameters	EPA Value (mg/l)	GSRI Value (mg/l)
BOD	228 ± 84	191
COD, low-level	10.3	9.4; 10.7
COD, high-level	370	366
TOC, low-level	4.0	4.1
TOC, high-level	145	146

TABLE 41. DATA FOR IN-HOUSE COD STANDARD

Date	True Value (mg/l)	Experimental Value (mg/l)
1/29/75	20.0	19.5
2/25/75	10.0	12.9
3/25/75	12.5	12.5
5/1/75	12.5	12.1

generated for low-level standards using the high-level method; however, the precision would be expected to be less for this situation.

The reasons for the generally lower-than-expected COD/TOC ratios are unknown, but may be related to a combination of changes occurring during sampling; handling and shipping, and associated with the analytical techniques used.

Quality Control

The data generated for this program were monitored through the use of various quality control measures. Quality control charts prepared according to EPA specifications were maintained throughout the study (5). As described in the methodology section, in-house standards or standards provided by EPA were analyzed with each set of samples. Representative portions of quality control charts for ammonia, chloride, COD, phenol, and sulfate are presented in Figures 14 through 18.

The quality control charts were constructed in three parts using data obtained from a blank, standard, and quality-control standard or from a quality-control standard in different units. The quality-control standard was a standard obtained from EPA or prepared in-house. Since it was necessary to use considerable amounts of the standard, it was generally prepared in-house, in which case it was prepared separately, thus eliminating the possibility of any error in preparation of the stock standard being carried over to the quality-control standard or vice versa. The data used to prepare the charts were in the form of both direct readout units and calculated concentration units.

The ammonia chart (Fig. 14) was constructed from the calculated concentration of the quality control standard, from the millivolt reading of the quality-control standard and from the millivolt reading of the 20 mg/l standard used for the standard curve. The 2 sigma and 3 sigma control limit lines were simply multiples of the standard deviation. A run was considered unacceptable if it went outside the 3 sigma limits. These limits were generally calculated for each section of the chart; however, in the case of ammonia, the rather large variation in millivolt reading without corresponding deviation in concentration made it impractical.

Results for several standards provided by EPA are shown in Table 42. The values obtained by GSRI for these standards are in good agreement with the values issued by EPA. The data obtained for the EPA trace metal reference standards (1171) and the mercury standards (1172) are shown in Table 43. The GSRI value is the average of several determinations in units of μg/l for each metal of interest.

Precision studies were conducted for both within-run and run-to-run conditions. The within-run precision is presented in Table 44 for ammonia, alkalinity, chloride, COD, conductivity, dissolved solids, fluoride, sulfate, and TKN. Run-to-run precision is shown in Table 45 for the same parameters plus phenol and in Table 46 for trace metal determinations.

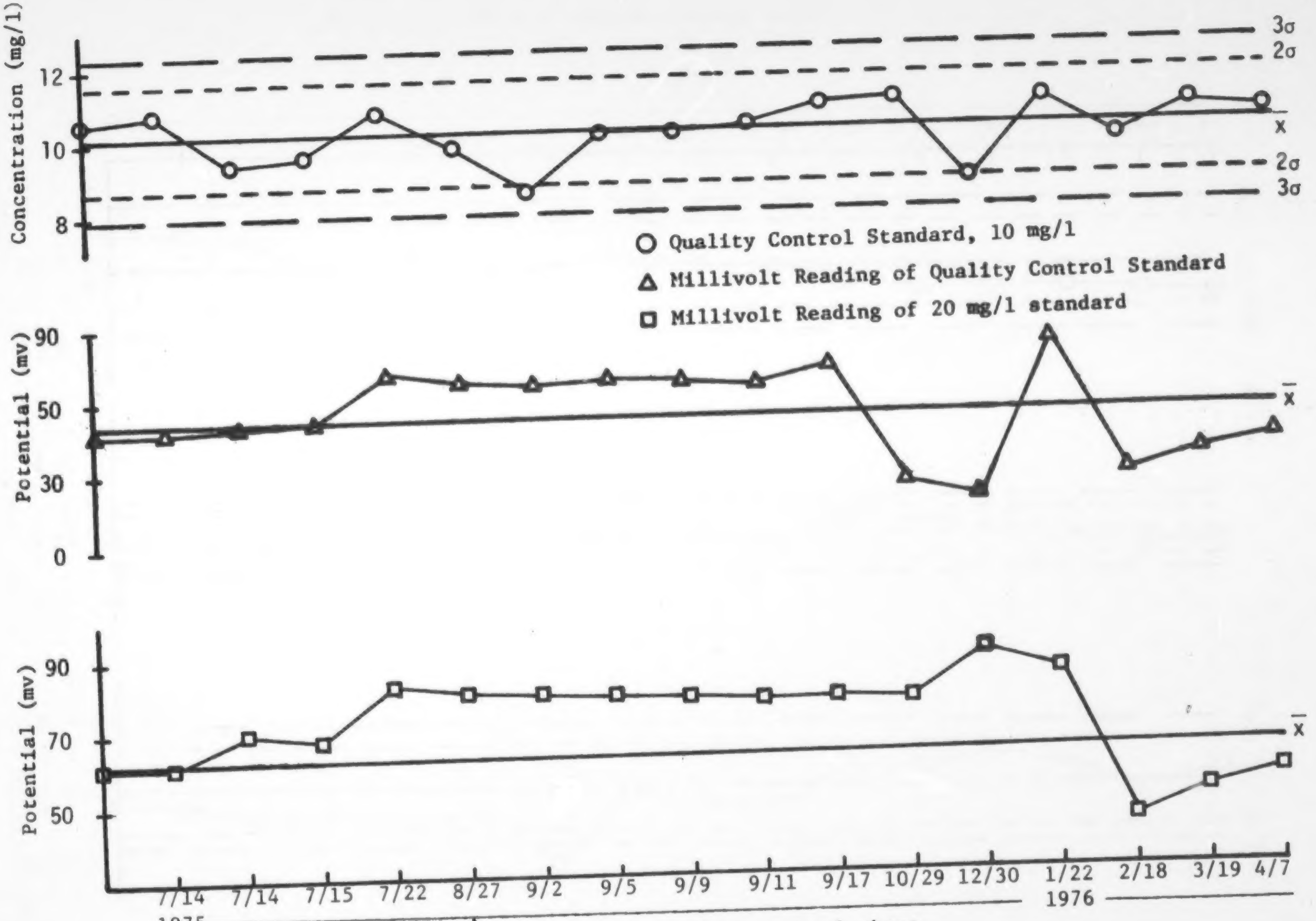

Figure 14, Ammonia quality control chart

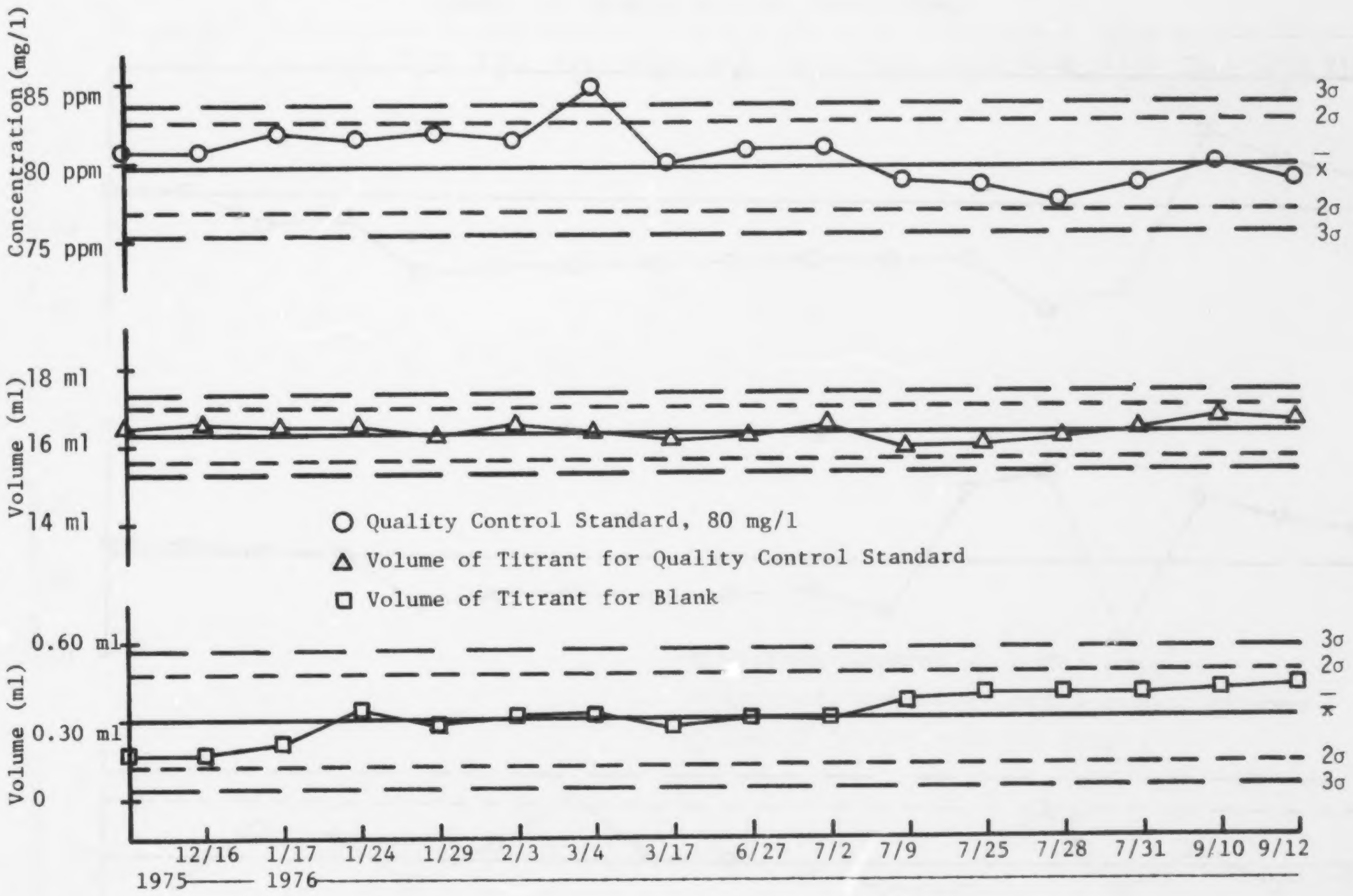

Figure 15. Chloride quality control chart

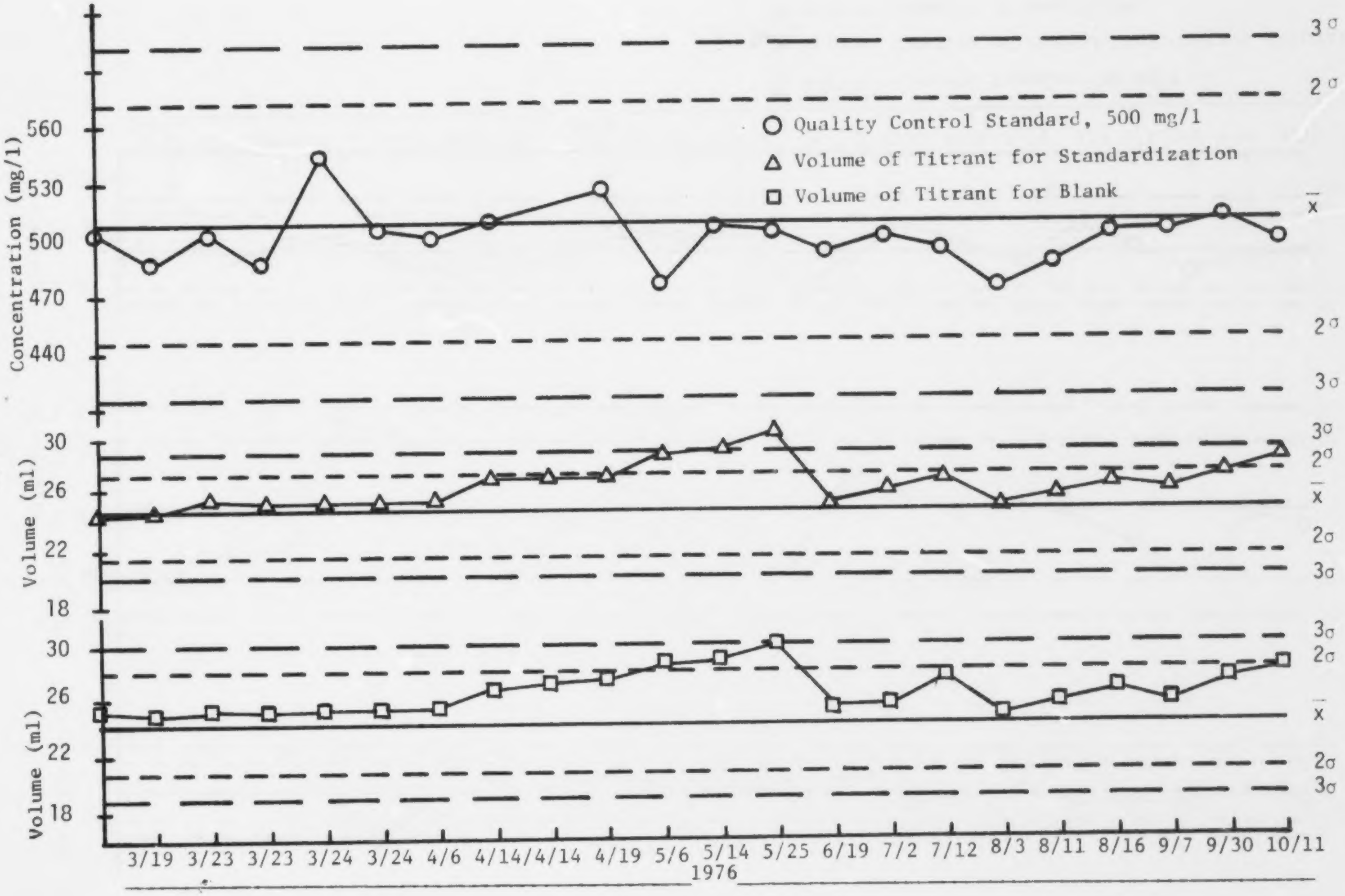

Figure 16. COD quality control chart.

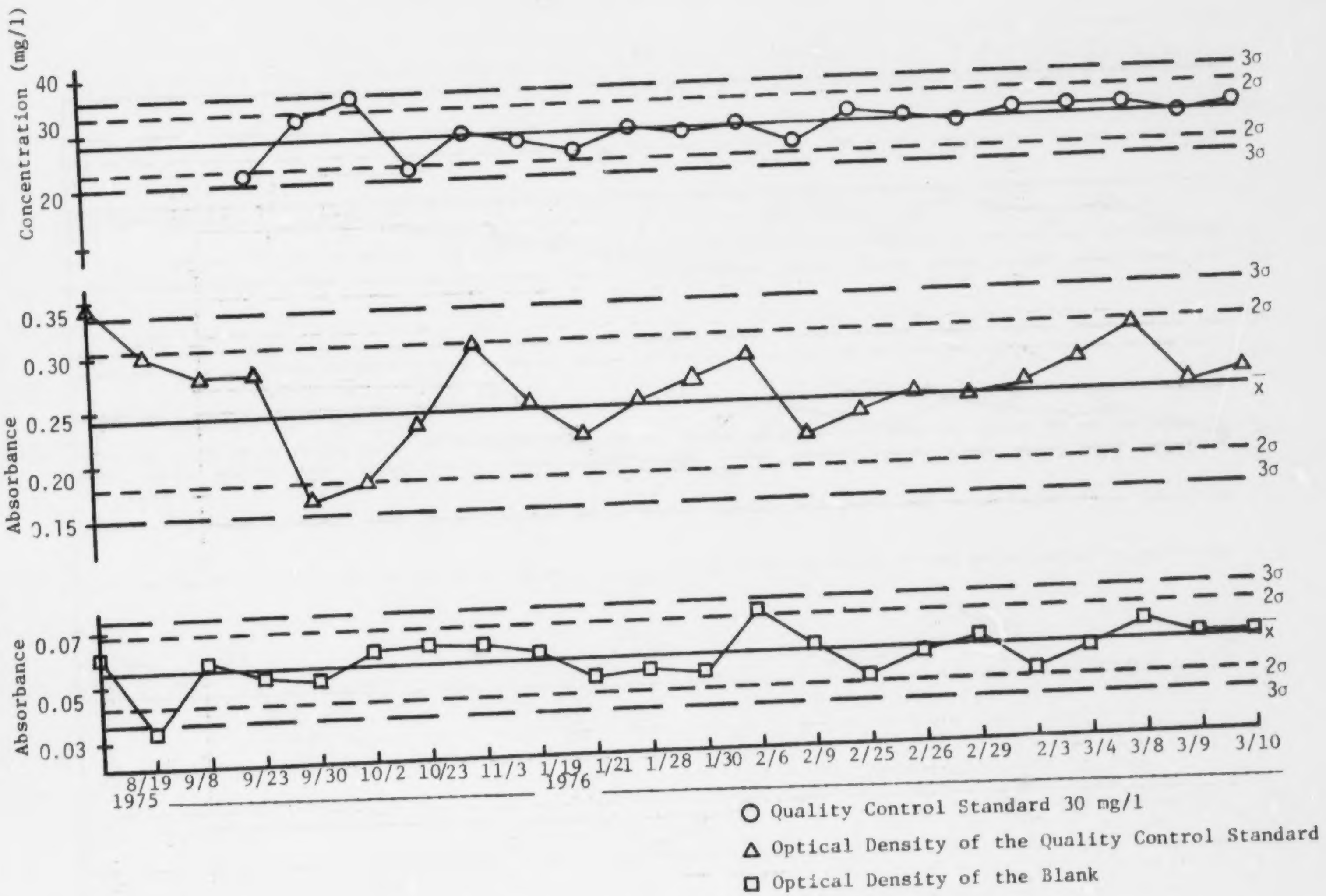

Figure 17. Phenol quality control chart

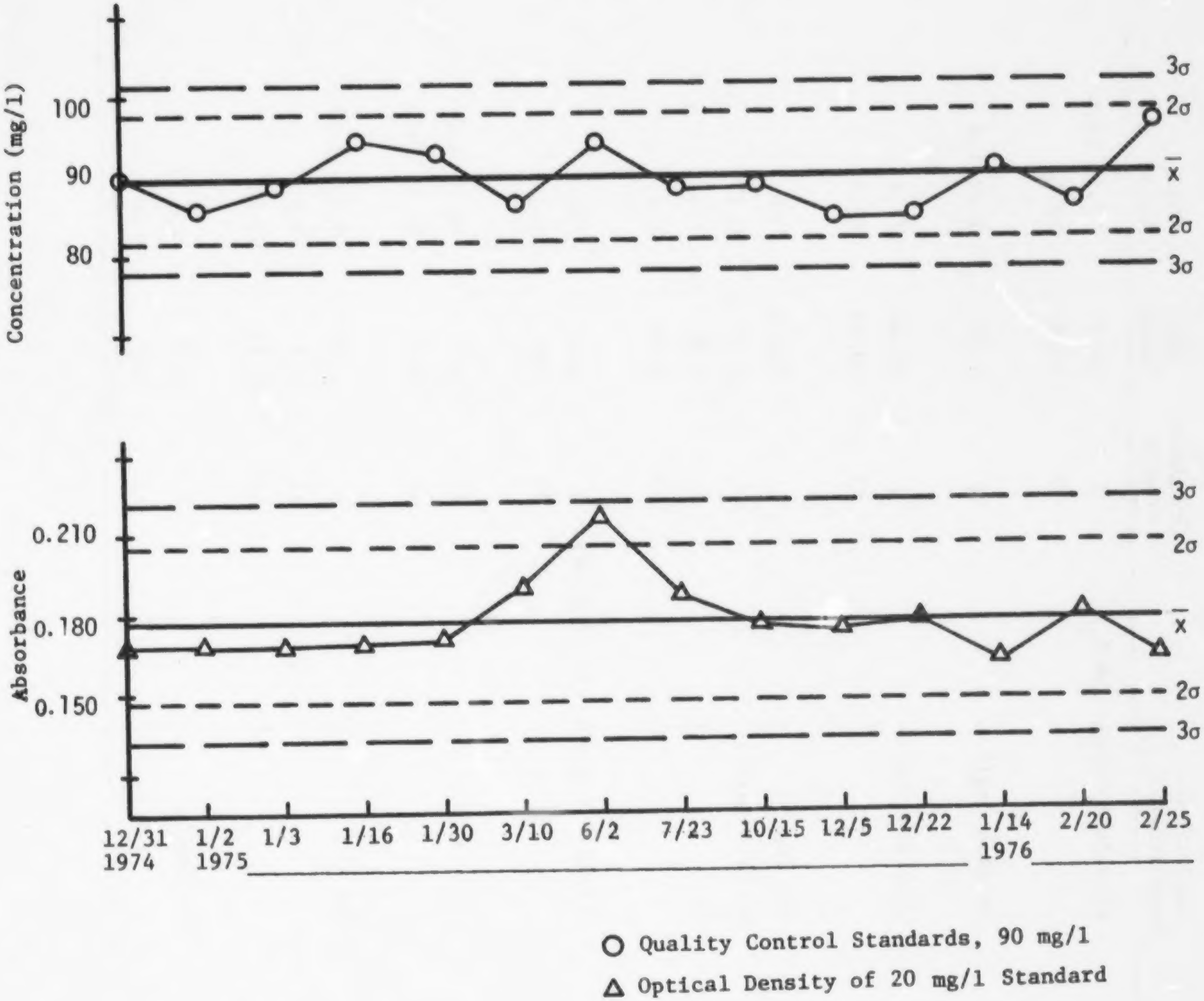

Figure 18. Sulfate quality control chart.

TABLE 42. COMPARISON OF VALUES OBTAINED BY GSRI FOR EPA REFERENCE STANDARDS

Analytical Measurement	EPA Standard Sample	EPA Value	GSRI Value
Alkalinity (mg/l $CaCO_3$)	I	17.9	17.6; 16.4
	II	55.8	52.8
Ammonia (mg/l)	I	1.47	1.4; 1.6
Chloride (mg/l)	I	18.46	17.4
	II	70.08	69.5
COD (mg/l)		308.3	300
Nitrate (mg/l)		0.17	0.17
pH	I	7.32	7.4
	II	7.75	7.6
Specific Conductivity (µmhos)	I	115	102
	II	535	520
Sulfate (mg/l)	I	8.4	10.0; 9.2
	II	86.0	87.3; 89.2
TKN (mg/l)	I	0.35	0.35; 0.27
	II	5.4	5.2
	III	6.33	7.8
TOC (mg/l)	I	4.0	4.1
	II	145	146

TABLE 43. COMPARISON OF VALUES OBTAINED BY GSRI FOR EPA TRACE METAL REFERENCE STANDARDS

Trace Metal	EPA Standard Sample	EPA Value (μg/l)	GSRI Value (μg/l)
Arsenic	I	22	19
	II	73	74
	III	278	259
Cadmium	I	1.8	2.6
	II	16	17
	III	73	64
Chromium	I	9.2	8.4
	II	83	81
	III	406	336
Copper	I	9.0	8.4
	II	67	66
	III	314	317
Lead	I	28	32
	II	92	92
	III	350	324
Manganese	I	13	13
Mercury	I	0.42	0.52
	II	2.4	2.5
	III	7.0	7.0
Selenium	I	5.0	4.2
	II	16	18
	III	48	46

TABLE 44. DATA FOR WITHIN-RUN PRECISION FOR SELECTED PARAMETERS

Parameter	True Value	Number η	Average $\bar{x}$	Standard Deviation σ	Minimum	Maximum
Ammonia (mg/l)	10	10	10	0.5	9.5	11
Alkalinity (mg/l $CaCO_3$)	300	7	294	0.4	293	295
Chloride (mg/l)	80	7	81.6	0.2	81.2	81.6
COD (mg/l)	250	7	251	1	250	253
Conductivity (μmhos)	700	10	720	4	700	730
Dissolved Solids (mg/l)	500	7	467	10	464	481
Fluoride (mg/l)	1	7	1	0	1	1
Sulfate (mg/l)	90	7	100	2	98	101
TKN (mg/l)	50	7	66	1	6	70

TABLE 45. DATA FOR RUN-TO-RUN PRECISION FOR SELECTED PARAMETERS

Parameter	True Value	Number η	Average $\bar{x}$	Standard Deviation σ	Minimum	Maximum
Ammonia (mg/l)	10	27	10.2	0.8	8.6	10.9
Alkalinity (mg/l $CaCO_3$)	300	16	290	6	274	301
Chloride (mg/l)	80	25	79	1	77	82
COD (high level)	500	23	497	12	474	538
COD low level)	20	17	20	1	19	23
Conductivity (μmhos)	717.8	8	726	17	711	756
Fluoride (mg/l)	0.8	6	0.8	0.05	0.7	0.8
Phenol (mg/l)	30	26	28	1	26	30
Sulfate (mg/l)	90	17	90	4	84	97
TKN (mg/l)	50	24	54	7	33	67

TABLE 46. DATA FOR RUN-TO-RUN PRECISION FOR TRACE METAL ANALYSES

Trace Metal	True Value (μg/l)	Number n	Average $\bar{x}$ (μg/l)	Standard Deviation σ	Minimum (μg/l)	Maximum (μg/l)
Arsenic	22	5	19	6	13	27
	73	3	74	8	67	82
	278	6	259	7	251	268
Cadmium	1.8	4	2.6	0.8	1.8	3.4
	16	5	17	3	14	22
	73	3	64	13	50	76
Chromium	9.2	4	8.4	1.3	7	10
	83	3	81	9	71	89
Copper	9	3	8.4	2.5	8.2	11
	67	3	66	13	55	80
	314	3	317	19	296	333
Lead	28	3	32	2	31	35
	92	4	92	13	78	110
	350	3	324	48	270	363
Mercury	0.42	10	0.52	0.2	0.27	0.80
	2.4	14	2.5	0.5	2.0	3.2
	7.0	11	7.0	1	6.1	7.7
Selenium	5.0	7	4.2	1.6	2.2	6.6
	16	5	18	4	12	22
	48	6	46	8	37	60

EFFLUENT QUALITY AND DRINKING WATER STANDARDS COMPLIANCE

The effluent quality observed for each treatment system during the sampling program was compared with quality standards set for drinking water by the 1975 Interim Primary Drinking Water Regulations, the 1962 Public Health Service Standards, and the U.S. EPA Quality Criteria for Water guidelines (Table 47). These comparative data are summarized in Tables 48 through 53. The mean, median, and exceedance ratio are tabulated for each pertinent parameter. The term "exceedance ratio" is used to describe the relationship between the number of samples which surpass prescribed drinking water limitations and the total number of samples evaluated. When used with the median, this ratio should give some indication as to the parameters of most concern. Table 53 summarizes these parameters in decreasing order of exceedance ratio for each treatment system evaluated.

The results indicate that as a rule the AWT facilities produced water of exceptional quality. None of the effluent samples exceeded drinking water standards with respect to pesticides, herbicides, radioactivity, color, and most chemical parameters. Bacteriological results were not included because of the small number of samples taken and the significant variations in the data. It should be noted that in almost all cases, plant operating records indicated total coliform counts less than 2/100 ml. Variations in parameter values were noted for each of the effluents. These variations may be influenced by changes in the raw wastewater composition and by the small number of samples taken, by possible errors in sampling, recording, and analytical procedures.

Parameters which were found to exceed drinking water standards in most of the effluents from the treatment systems included total dissolved solids, nitrogen (ammonia and nitrate), phenol, odor, CCE, turbidity, and specific heavy metals. These are discussed briefly below.

Total Dissolved Solids (TDS)

By the nature of the treatment processes, accumulation of mineral content is inherent in water reuse. It has been estimated that one municipal usage of water can increase the concentration of TDS by 300 mg/l (18). Escondido, which employs reverse osmosis, was the only location where excessive TDS content was not a problem. Orange County product water exhibited excessive sulfate concentrations. These results stress the importance of suitable blending water sources.

Nitrogen

Nitrogen in the form of ammonia and nitrate was excessive in most effluents on occasion. Ammonia stripping towers at Lake Tahoe experienced operating difficulties with $CaCO_3$ scaling, and removal efficiency was particularly low during cold weather operation. The Orange County plant receives unusually high concentrations of ammonia (approximately 60 mg/l) due to industrial waste discharges. Orange County's ammonia stripping process reduces these concentrations by an average of 60%. The Blue Plains Treatment System 2 maintains residual ammonia concentrations within acceptable limits

TABLE 47. DRINKING WATER STANDARDS*

	Parameters	Source**	
		1	2
	pH		
Physical			
	Color		15 CU
	Odor		3 Ton
	Turbidity	1 JTU	5 JTU
Microbiological			
	Coliform Organisms	1/100 ml	
Chemical		(mg/l)	(mg/l)
	Alkyl Benzene Sulfonate (ABS)		0.5
	Arsenic	0.05	0.01
	Barium	1	1
	Cadmium	0.01	0.01
	Carbon chloroform extract (CCE)	0.7**	0.2
	Chloride		250
	Chromium (+6)	0.05	0.05
	Cyanide	0.2	0.2
	Copper		1
	Fluoride	1.4 - 2.4	0.8 - 1.7
	Iron		0.3
	Lead	0.05	0.05
	Manganese		0.05
	Mercury	0.002	
	Nitrates (as N)	10	10
	Phenols		0.001
	Selenium	0.01	0.01
	Silver	0.05	0.05
	Sulfate		250
	Total dissolved solids		500
	Zinc		5
Pesticides (mg/l)			
	Aldrin	0.001**	
	Chlordane	0.003**	
	DDT	0.05**	
	Dieldrin	0.001**	
	Endrin	0.0002	
	Heptachlor	0.0001**	
	Heptachlor epoxide	0.0001**	
	Lindane	0.004	
	Methyoxychlor	0.1	
	Toxaphene	0.005	

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*1975 limits were used for exceedance ratios where available; otherwise 1962 criteria were employed.

**See references, next page.

-continued-

TABLE 47. (Continued)

Parameters	Source**	
	1	2
Herbicides (mg/l)		
2,4-D	0.1	
2,4,5-TP Silvex	0.01	
Radioactivity (μμc/l)		
Gross beta		1000
Radium - 226		3
Strontium - 90		10

*References

1. National Interim Primary Drinking Water Regulations, Federal Register, Volume 40, No. 248, 59565, December 24, 1975.

2. Public Health Service Drinking Water Standards, U. S. Department of Health, Education, and Welfare, 1962.

**Proposed, but omitted in final standards.

TABLE 48. RESULTS OF AWT PLANT PERFORMANCE VS. COMPLIANCE TO DRINKING WATER STANDARDS

LAKE TAHOE

Parameter	Drinking Water Standard	Mean	Median	Exceedance Ratio*
Physical				
Color	15 CU	4	3	0/13
Odor	3 TON	2	1	1/13
Turbidity	1 JTU	1.35	0.96	9/12
Microbiological				
Total Coliform	1/100 ml	27.3	2	7/12
Chemical				
Ammonia (as N)	0.5 mg/1**	15.3		13/13
Arsenic	50 μg/1	27.8	10	2/13
Barium	1000 μg/1	25	25	0/13
Cadmium	10 μg/1	2.7	1	1/13
Carbon Chloroform Extract (CCE)	700 μg/1	830	650	3/8
Chloride	250 mg/1	65.3	43.0	0/13
Chromium (+6)	50 μg/1	2.4	1	0/13
Cyanide	200 μg/1	11	5	0/13
Copper	1000 μg/1	50.9	39	0/13
Fluoride	1.4 to 2.4 mg/1	0.24	0.22	0/13
Iron	300 μg/1	249	140	3/13
Lead	50 μg/1	5	1	0/13
Manganese	50 μg/1	11.5	8	0/13
Mercury	2 μg/1	0.39	0.3	0/13
Nitrates (as N)	10 mg/1	1.65	0.7	0/13
Phenols	1 μg/1	5.8	5.0	7/12
Selenium	10 μg	*152	165	12/13
Silver	50 μg/1	1	1	0/13
Sulfate	250 mg/1	28.1	27.8	0/13
Total Dissolved Solids	500 mg/1	387	414	1/13
Zinc	5000 μg/1	1010	280	0/13

*Number of samples exceeding limit/total number of samples (based on Drinking Water Standard indicated).

**Permissible Criteria for Public Water Supplies from Water Quality Criteria April 1, 1968, Federal Water Pollution Control Adm., Washington, D. C.

-continued-

TABLE 48. Continued

LAKE TAHOE

Parameter	Drinking Water Standard	Mean	Median	Exceedance Ratio
Pesticides				
Aldrin	1 µg/l	ND***		0/13
Chlordane	3 µg/l	ND		0/13
DDT	50 µg/l	ND		0/13
Dieldrin	1 µg/l	ND		0/13
Endrin	0.2 µg/l	ND		0/13
Heptachlor	0.1 µg/l	ND		0/13
Lindane	4 µg/l	ND		0/13
Methyoxychlor	100 µg/l	ND		0/13
Herbicides				
2,4-D	100 µg/l	ND		0/13
2,4,5-TP Silvex	10 µg/l	ND		0/13
Radioactivity				
Gross alpha	15 µµc/l	1.6	1.1	0/13
Gross beta	1000 µµc/l	8.9	7.9	0/13
Tritium	20,000 µµc/l	499	552	0/13

***ND - none detected

TABLE 49. RESULTS OF AWT PLANT PERFORMANCE VS. COMPLIANCE TO DRINKING WATER STANDARDS

Parameter	Drinking Water Standard	BLUE PLAINS SYSTEM 1 Mean	Median	Exceedance Ratio*	BLUE PLAINS SYSTEM 2 Mean	Median	Exceedance Ratio*
Physical							
Color	15 CU	2	2	0/3	2.5	2.5	0/6
Odor	3 TON	8	9	2/2	25	15	5/6
Turbidity	1 JTU	5	5	0/2	1.0	0.99	2/6
Microbiological							
Total Coliform	1/100 ml	1200	1200	2/2	8	2	4/6
Chemical							
Ammonia (as N)	0.5 mg/1**	0.88	0.65	2/3	0.1	0.04	0/6
Arsenic	50 µg/1	19	10	0/3	1.0	10	0/6
Barium	1000 µg/1	100	25	0/3	41	28	0/6
Cadmium	10 µg/1	1	1	0/3	1.3	1	0/6
Carbon Chloroform Extract (CCE)	700 µg/1	1300	1300	2/2	68	60	0/6
Chloride	250 mg/1	188	183	0/3	66.1	69.8	0/6
Chromium (+6)	50 µg/1	27	19	1/3	11	9	0/6
Cyanide	200 µg/1	43	40	0/3	5	5	0/6
Copper	1000 µg/1	15	13	0/3	45.5	38	0/6
Fluoride	1.4 to 2.4 mg/1	1.2	1.3	0/3	0.75	80	0/6
Iron	300 µg/1	225	255	0/3	61	50	0/6
Lead	50 µg/1	27	19	1/3	1	1	0/6
Manganese	50 µg/1	15	10	0/3	6.9	5	0/6
Mercury	2 µg/1	0.3	0.3	0/3	0.63	0.53	0/6
Nitrates (as N)	10 mg/1	0.5	0.5	0/3	2.90	0.50	1/6
Phenols	1 ug/1	5	5	1/2	7.5	5	1/6
Selenium	10 µg	10	10	0/3	37	10	1/6
Silver	50 µg/1	4.3	4	0/3	0.71	0.40	0/6
Sulfate	200 mg/1	70	69	0/3	49.0	49.6	0/6
Total Dissolved Solids	500 mg/1	522	524	3/3	339	341	0/6
Zinc	5000 µg/1	59	64	0/3	54	51	0/6

*Number of samples exceeding limit/total number of samples (based on Drinking Water Standard indicated).

**Permissible Criteria for Public Water Supplies from Water Quality Criteria April 1, 1968, Federal Water Pollution Control Adm., Washington, D. C.

-continued-

TABLE 49. Continued

Parameter	Drinking Water Standard	BLUE PLAINS SYSTEM 1			BLUE PLAINS SYSTEM 2		
		Mean	Median	Exceedance Ratio	Mean	Median	Exceedance Ratio
Pesticides							
Aldrin	1 µg/l	ND***		0/2	ND	ND	0/6
Chlordane	3 µg/l	ND		0/2	ND	ND	0/6
DDT	50 µg/l	ND		0/2	ND	ND	0/6
Dieldrin	1 µg/l	ND		0/2	ND	ND	0/6
Endrin	0.2 µg/l	ND		0/2	ND	ND	0/6
Heptachlor	0.1 µg/l	ND		0/2	ND	ND	0/6
Lindane	4 µg/l	ND		0/2	ND	ND	0/6
Methoxychlor	100 µg/l	ND		0/2	ND	ND	0/6
Herbicides							
2,4-D	100 µg/l	ND		0/2	ND	ND	0/6
2,4,5-TP Silvex	10 µg/l	ND		0/2	ND	ND	0/6
Radioactivity							
Gross alpha	15 µµc/l	1.4	1.4	0/3	1.5	2.6	0/6
Gross beta	1000 µµc/l	6.2	5.9	0/3	9.9		0/6
Tritium	20,000 µµc/l	183	150	0/3	266.8	277	0/6

***ND - none detected

TABLE 50. RESULTS OF AWT PLANT PERFORMANCE VS. COMPLIANCE TO DRINKING WATER STANDARDS

		ORANGE COUNTY		
Parameter	Drinking Water Standard	Mean	Median	Exceedance Ratio*
Physical				
Color	15 CU			
Odor	3 TON	9	9	6/6
Turbidity	1 JTU	1.1	1.1	3/6
Microbiological				
Total Coliform	1/100 ml	2	0	2/6
Chemical				
Ammonia (as N)	0.5 mg/l**	14.7	14.2	6/6
Arsenic	50 µg/l	10	10	0/6
Barium	1000 µg/l	25	25	0/6
Cadmium	10 µg/l	1.8	1	0/6
Carbon Chloroform Extract (CCE)	700 µg/l	200	205	0/4
Chloride	250 mg/l	222	225	0/6
Chromium (+6)	50 µg/l	67	57	5/6
Cyanide	200 µg/l	5	5	0/6
Copper	1000 µg/l	40	44	0/6
Fluoride	1.4 to 2.4 mg/l	0.74	0.73	0/6
Iron	300 µg/l	35	34	0/6
Lead	50 µg/l	13	12	0/6
Manganese	50 µg/l	2.7	3	0/6
Mercury	2 µg/l	0.53	0.43	0/6
Nitrates (as N)	10 mg/l			
Phenols	1 µg/l	7.5	5	1/6
Selenium	10 µg	10	10	
Silver	50 µg/l	36.4	33.9	0/6
Sulfate	200 mg/l	309	310	6/6
Total Dissolved Solids	500 mg/l	952	937	6/6
Zinc	5000 µg/l	488	298	0/6

*Number of samples exceeding limit/total number of samples (based on Drinking Water Standard indicated).

**Permissible Criteria for Public Water Supplies from Water Quality Criteria April 1, 1968, Federal Water Pollution Control Adm., Washington, D. C.

-continued-

TABLE 50. Continued

Parameter	ORANGE COUNTY Drinking Water Standard	Mean	Median	Exceedance Ratio
Pesticides				
Aldrin	1 μg/1	ND***		0/6
Chlordane	3 μg/1	ND		0/6
DDT	50 μg/1	ND		0/6
Dieldrin	1 μg/1	ND		0/6
Endrin	0.2 μg/1	ND		0/6
Heptachlor	0.1 μg/1	ND		0/6
Lindane	4 μg/1	ND		0/6
Methoxychlor	100 μg/1	ND		0/6
Herbicides				
2,4-D	100 μg/1	ND		0/6
2,4,5-TP Silvex	10 μg/1	ND		0/6
Radioactivity				
Gross alpha	15 μμc/1	4.8	5.0	0/6
Gross beta	1000 μμc/1	14.7	12.7	0/6
Tritium	20,000 μμc/1	833	820	0/6

***ND - none detected

TABLE 51. RESULTS OF AWT PLANT PERFORMANCE VS. COMPLIANCE TO DRINKING WATER STANDARDS

		POMONA SYSTEM 1			POMONA SYSTEM 2		
Parameter	Drinking Water Standard	Mean	Median	Exceedance Ratio*	Mean	Median	Exceedance Ratio*
Physical							
Color	15 CU	2	2	0/9	3	3	0/9
Odor	3 TON	5	4	6/9	2	1	2/9
Turbidity	1 JTU	0.9	0.73	3/7	0.7	0.4	1/7
Microbiological							
Total Coliform	1/100 ml	3	0	3/9	174	130	8/9
Chemical							
Ammonia (as N)	0.5 mg/1**	4.8	2.0	5/9	7.3	7.0	9/9
Arsenic	50 μg/1	25	24	0/9	31	10	2/9
Barium	1000 μg/1	67	25	0/9	25	25	0/9
Cadmium	10 μg/1	2	1	0/9	1.2	1	0/9
Carbon Chloroform Extract (CCE)	700 μg/1	1200	650	4/8	520	340	1/8
Chloride	250 mg/1	87.9	81.5	0/9	106	93.3	0/9
Chromium (+6)	50 μg/1	39	30	2/9	18.4	17	0/9
Cyanide	200 μg/1	5	5	0/9	5	5	0/9
Copper	1000 μg/1	48	48	0/9	40	27	0/9
Fluoride	1.4 to 2.4 mg/1	0.7	0.56	0/9	0.79	0.71	0/9
Iron	300 μg/1	168	79	2/9	432	40	1/9
Lead	50 μg/1	6	1	0/9	4.4	1	0/9
Manganese	50 μg/1	14	8	1/9	7.8	7	0/9
Mercury	2 μg/1	3.1	0.31	2/9	0.51	0.3	0/9
Nitrates (as N)	10 mg/1	6.5	4.5	2/9	7.9	2.7	3/9
Phenols	1 μg/1	5.7	5	3/9	4.6	5	3/9
Selenium	10 μg	10	10	5/9	10	10	0/9
Silver	50 μg/1	0.65	0.9	0/9	2	0.081	0/9
Sulfate	200 mg/1	77.1	79.0	0/9	85.6	86	0/9
Total Dissolved Solids	500 mg/1	517	513	7/9	512	538	6/9
Zinc	5000 μg/1	84	62	0/10	58.4	48	0/9

*Number of samples exceeding limit/total number of samples (based on Drinking Water Standard indicated.)

**Permissible Criteria for Public Water Supplies from Water Quality Criteria April 1, 1968, Federal Water Pollution Control Adm., Washington, D. C.

-continued-

TABLE 51 Continued

POMONA

Parameter	Drinking Water Standard	SYSTEM 1 Mean	SYSTEM 1 Median	SYSTEM 1 Exceedance Ratio	SYSTEM 2 Mean	SYSTEM 2 Median	SYSTEM 2 Exceedance Ratio
Pesticides							
Aldrin	1 μg/l	ND***	ND	0/9	ND	ND	0/9
Chlordane	3 μg/l	ND	ND	0/9	ND	ND	0/9
DDT	50 μg/l	ND	ND	0/9	ND	ND	0/9
Dieldrin	1 μg/l	ND	ND	0/9	ND	ND	0/9
Endrin	0.2 μg/l	ND	ND	0/9	ND	ND	0/9
Heptachlor	0.1 μg/l	ND	ND	0/9	ND	ND	0/9
Lindane	4 μg/l	ND	ND	0/9	ND	ND	0/9
Methoxychlor	100 μg/l	ND	ND	0/9	ND	ND	0/9
Herbicides							
2,4-D	100 μg/l	0.023	ND	0/9	0.095	ND	0/9
2,4,5-TP Silvex	10 μg/l	0.016	ND	0/9	0.083	ND	0/9
Radioactivity							
Gross alpha	15 μμc/l	2.3	1.2	0/9	2.9	2.0	0/9
Gross beta	1000 μμc/l	16.9	13.5	0/9	15.6	17.4	0/9
Tritium	20,000 μμc/l	528.6	450	0/9	428	400	0/9

***ND - None detected

-continued-

TABLE 51. Continued

POMONA SYSTEM 3

Parameter	Drinking Water Standard	Mean	Median	Exceedance Ratio*
Physical				
Color	15 CU			
Odor	3 TON	7	4	4/8
Turbidity	1 JTU	1.2	0.99	4/8
Microbiological				
Total Coliform	1/100 ml	615	17	8/9
Chemical				
Ammonia (as N)	0.5 mg/l**	7.7	4.7	9/9
Arsenic	50 μg/l	10	10	0/9
Barium	1000 μg/l	25	25	0/9
Cadmium	10 μg/l	1	1	0/9
Carbon Chloroform Extract (CCE)	700 μg/l	800	400	3/9
Chloride	250 mg/l	98.6	97.3	0/9
Chromium (+6)	50 μg/l	62	55	5/9
Cyanide	200 μg/l	6	5	0/9
Copper	1000 μg/l	50	44	0/9
Fluoride	1.4 to 2.4 mg/l	0.7	0.71	0/9
Iron	300 μg/l	58	46	0/9
Lead	50 μg/l	7	7	0/9
Manganese	50 μg/l	7	8	0/9
Mercury	2 μg/l	0.63	0.54	0/9
Nitrates (as N)	10 mg/l	14.7	8.0	4/9
Phenols	1 μg/l	6.5	5	3/9
Selenium	10 μg	10	10	0/9
Silver	50 μg/l	43.3	40.9	2/9
Sulfate	200 mg/l	89.0	83	0/9
Total Dissolved Solids	500 mg/l	571	582	8/9
Zinc	5000 μg/l	66	52	0/9

*Number of samples exceeding limit/total number of samples (based on Drinking Water Standard indicated).

**Permissible Criteria for Public Water Supplies from Water Quality Criteria April 1, 1968, Federal Water Pollution Control Adm., Washington, D. C.

-continued-

TABLE 51. Continued

POMONA

SYSTEM 3

Parameter	Drinking Water Standard	Mean	Median	Exceedance Ratio
Pesticides				
Aldrin	1 µg/l	ND***	ND	0/9
Chlordane	3 µg/l	ND	ND	0/9
DDT	50 µg/l	ND	ND	0/9
Dieldrin	1 µg/l	ND	ND	0/9
Endrin	0.2 µg/l	ND	ND	0/9
Heptachlor	0.1 µg/l	ND	ND	0/9
Lindane	4 µg/l	ND	ND	0/9
Methoxychlor	100 µg/l	ND	ND	0/9
Herbicides				
2,4-D	100 µg/l	ND	ND	0/9
2,4,5-TP Silvex	10 µg/l	ND	ND	0/9
Radioactivity				
Gross alpha	15 µµc/l	5.9	5.8	0/9
Gross beta	1000 µµc/l	21.8	22.6	0/9
Tritium	20,000 µµc/l	207	160	0/9

***ND - None detected.

TABLE 52. RESULTS OF AWT PLANT PERFORMANCE VS. COMPLIANCE TO DRINKING WATER STANDARDS

		DALLAS			ESCONDIDO	
Parameter	Drinking Water Standard	Mean	Median	Exceedance Ratio*	Mean	Exceedance Ratio*
Physical						
Color	15 CU				1	0/1
Odor	3 TON	13	8	7/7	14	1/1
Turbidity	1 JTU	0.2	0.13	0/8	0.8	0/1
Microbiological						
Total Coliform	1/100 ml	7	0	3/7	0	0/1
Chemical						
Ammonia (as N)	0.5 mg/1**	1.3	0.08	2/8	1	1/1
Arsenic	50 μg/1	36	21	2/7	ND***	0/1
Barium	1000 μg/1	158	25	0/8	ND	0/1
Cadmium	10 μg/1	1	1	0/8	ND	0/1
Carbon Chloroform Extract (CCE)	700 μg/1	400	200	1/7		
Chloride	250 mg/1	73.1	74.9	0/8	24.3	0/1
Chromium (+6)	50 μg/1	12	4.5	1/8	ND	0/1
Cyanide	200 μg/1	5	5	0/8	0.06	0/1
Copper	1000 μg/1	6	4	0/8	10	0/1
Fluoride	1.4 to 2.4 mg/1	1.3	1.3	0/8	0.3	0/1
Iron	300 μg/1	125	93	1/8	20	0/1
Lead	50 μg/1	5	1	0/8	ND	0/1
Manganese	50 μg/1	5	5	0/8	ND	0/1
Mercury	2 μg/1	0.3	0.3	0/6	0.3	0/1
Nitrates (as N)	10 mg/1	4.8	4.6	0/8	9	0/1
Phenols	1 μg/1	6.5	7.2	6/8	7.4	1/1
Selenium	10 μg	63	35	5/8	180	1/1
Silver	50 μg/1	0.53	1	0/8	0.2	0/1
Sulfate	200 mg/1	92.1	90.5	0/8	1.6	0/1
Total Dissolved Solids	500 mg/1	468	478	3/8	82	0/1
Zinc	5000 μg/1	42	24	0/8	20	0/1

*Number of samples exceeding limit/total number of samples (based on Drinking Water Standard indicated).

**Permissible Criteria for Public Water Supplies from Water Quality Criteria April 1, 1968, Federal Water Pollution Control Adm., Washington, D. C.

***ND - None detected.

TABLE 52. Continued

		DALLAS			ESCONDIDO	
Parameter	Drinking Water Standard	Mean	Median	Exceedance Ratio	Mean	Exceedance Ratio
Pesticides						
Aldrin	1 μg/1	ND	ND	0/8	ND	0/1
Chlordane	3 μg/1	0.039	ND	0/8	ND	0/1
DDT	50 μg/1	ND	ND	0/8	ND	0/1
Dieldrin	1 μg/1	ND	ND	0/8	ND	0/1
Endrin	0.2 μg/1	ND	ND	0/8	ND	0/1
Heptachlor	0.1 μg/1	0.007	ND	0/8	ND	0/1
Lindane	4 μg/1	ND	ND	0/8	ND	0/1
Methoxychlor	100 μg/1	ND	ND	0/8	ND	0/1
Herbicides						
2,4-D	100 μg/1	0.032	ND	0/8	ND	0/1
2,4,5-TP Silvex	10 μg/1					
Radioactivity						
Gross alpha	15 μμc/1	1.4	1.2	0/8	--	
Gross beta	1000 μμc/1	10.1	10.4	0/8	--	
Tritium	20,000 μμc/1	581	630	0/8	--	

TABLE 53. PARAMETERS EXCEEDING DRINKING WATER STANDARDS

Parameter	Median	Exceedance Ratio	Parameter	Median	Exceedance Ratio	Parameter	Median	Exceedance Ratio	Parameter	Median	Exceedance Ratio
TAHOE			BLUE PLAINS SYSTEM 1			BLUE PLAINS SYSTEM 2			DALLAS		
NH_3-N	15.0 mg/1	13/13	TDS	524 mg/1	3/3	Odor	15.0 TON	5/6	Odor	8 TON	7/7
Selenium	16.5 μg/1	12/13	Odor	9 TON	2/2	Turbidity	0.99 TU	2/6	Phenol	7.2 μg/1	6/8
Turbidity	1 JTU	9/12	CCE	1300 μg/1	2/2	NO_3-N	0.5 mg/1	1/6	Se	35 μg/1	5/8
Phenol	5 μg/1	7/12	NH_3-N	0.65 mg/1	2/3	Phenol	5 μg/1	1/6	TDS	478 mg/1	3/8
CCE	650 μg/1	3/8	Phenol	5 μg/1	1/2	Se	10 μg/1	1/6	As	21 μg/1	2/7
Iron	140 μg/1	3/13	Cr	19 μg/1	1/3				NH_3-N	0.08 mg/1	2/8
As	10 μg/1	2/13	Pb	19 μg/1	1/3				CCE	200 μg/1	1/7
TDS	414 mg/1	1/13							Cr	4.5 μg/1	1/8
Odor	1 TON	1/13							Iron	93 μg/1	1/8
Cd	1 μg/1	1/13									
POMONA SYSTEM 1			POMONA SYSTEM 2			POMONA SYSTEM 3			ORANGE COUNTY		
TDS	513 mg/1	7/9	NH_3-N	7.0 mg/1	8/9	NH_3-N	4.7 mg/1	9/9	NH_3-N	14.2 mg/1	6/6
Odor	4 TON	6/9	TDS	538 mg/1	6/9	TDS	582 mg/1	8/9	TDS	937 mg/1	6/6
NH_3-N	2.0 mg/1	5/9	Phenol	5 μg/1	3/9	Cr	55 μg/1	5/9	Sulfate	310 mg/1	6/6
Se	10 μg/1	5/9	NO_3-N	2.7 mg/1	3/9	Odor	4 TON	4/8	Odor	9 TON	6/6
CCE	650 μg/1	4/8	As	10 μg/1	2/9	Turbidity	0.99 TU	4/8	Cr	57 μg/1	5/6
Turbidity	0.73 TU	3/7	Odor	1 TON	2/9	NO_3-N	8.0 mg/1	4/9			
Phenol	5 μg/1	3/9	Turbidity	0.40 TU	1/7	Phenol	5 μg/1	3/9	Turbidity	1.1 NTU	3/6
Cr	30 μg/1	2/9	CCE	340 μg/1	1/8	CCE	400 μg/1	3/9	Phenol	5 μg/1	1/6
NO_3-N	4.5 mg/1	2/9	Iron	40 μg/1	1/9	Ag	40.9 μg/1	2/9			
Fe	7.9 μg/1	2/9							ESCONDIDO		
Hg	0.31 μg/1	2/9							Odor	14 TON	1/1
Mn	8 μg/1	1/9							Phenol	7.4 μg/1	1/1
									Se	180 μg/1	1/1
									NH_3-N	1 mg/1	1/1

by biological nitrification-denitrification. Upsets with the breakpoint chlorination process in System 1 accounted for the median value of 0.65 mg/l. Blue Plains plant personnel, however, indicated that residuals of 0.4 to 0.6 mg/l and TKN residuals of 1.2 to 1.5 mg/l are possible with no upsets.

Phenol

Phenolic compounds in levels exceeding the 1 μg/l standard were found in all effluents studied. Biological-AWT methods as currently employed appear to be inadequate in removing phenol to the 1 μg/l requirement.

Odor

The threshold odor numbers (TON) of all the samples are higher than would be expected for the relatively low levels of organic materials in all the effluents sampled. Chlorination for disinfection was practiced in most of the treatment systems monitored and the presence of residual chlorine may be responsible for the high TON values. Also, it is best to determine TON on fresh samples. Repeated handling, transporting, and storage of samples such as that which occurred in this project can cause changes in samples that produce very slight, but to the sense of smell, significant changes that alter the sample odor characteristics. Since the test is subjective, differences in the make-up of the odor panel and testing procedure can affect results. The inability of waste treatment processes to remove phenol to the recommended limit may contribute to the high exceedance ratios observed for odor. However, this explanation appears unlikely in view of the high TONs reported.

Turbidity

Effluent turbidity concentrations were for most samples at or below 1 JTU. This standard was exceeded on occasion. Turbidity values were, however, always less than 5 units, which is specified as the limit by the 1962 Drinking Water Standards, and is allowed under some conditions by the 1975 standards.

Carbon Chloroform Extract (CCE)

Presence of CCE surpassed recommended levels for all facilities except Escondido and Orange County. However, the determination of CCE is influenced by many variables which may effect these results. For example, sterile carbon is employed in the determination of sample concentration, whereas in practice, bioactivity can greatly affect the adsorptive properties and hence efficiency of field carbon adsorption columns.

Heavy Metals

In general, median values for selected heavy metals did not exceed allowable drinking water limits. Removal efficiency of heavy metals is dependent upon the specific metal, influent concentration of the metal, redox potential, pH, carbon bioactivity, coagulant addition, ionic strength of carrier water, and other operating and environmental factors. Chemical treatment with lime, for example, results in a reduction of many heavy metal concentrations due to insoluble hydroxides formed at high pH. Pomona, which did not employ lime treatment, experienced the highest diversity of specific heavy metal exceedance ratios. It has been observed that as the influent concentration of the heavy metal decreases, so does AWT removal efficiency. Selenium appeared to be the most persistent trace metal, characterized by exceedance ratios for effluents from all facilities except Orange County.

Comments on Effluent Quality and Drinking Water Standards Compliance

In general, the treatment systems sampled in this project were not designed to produce water of potable quality. Each system was part of an independent, full-scale or pilot scale project with specific, individual goals. The systems were selected primarily because of availability and because effluent quality exceeded that of secondary treatment systems. All the systems, however, were characterized by high quality effluents and produced water approaching potable quality. It is apparent that by effectively sequencing selected processes used in these systems, a treatment system can be designed that will consistently meet Drinking Water Standards.

All of the treatment systems had been in stable operation prior to initiating the sampling program with the exception of the Orange County Water District's Water Factory 21. This facility was just entering a period of initial start-up when samples were taken for this project. None of the water being treated during this period was injected into the ground and the plant was being operated to optimize operations prior to actual injection in October 1976. For this reason some of the effluent constituents were present in higher concentrations than would be allowed if optimum operation and injection were underway.

REFERENCES

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APPENDIX A

CHEMICAL, PHYSICAL, AND BIOLOGICAL ANALYTICAL DATA ON EFFLUENT SAMPLES TAKEN FROM EACH ADVANCED WASTEWATER TREATMENT PLANT

TABLE A-1. ANALYTICAL DATA, POMONA PROCESS ONE

	1 9/20/74	2 10/2/74	3 10/7/74	4 10/21/74	5 11/11/74	6 12/5/74	7 4/24/75	8 9/16/75	9 11/7/75	Low	High	n	$\bar{x}$	σ
Total Coliform (No/100 ml)	0	0	0	2	8	0	11	0	0	0	8	9	2	-
Fecal Coliform (No/100 ml)	0	0	0	0	1	0	0	0	0	0	1	9	-	-
Total Plate Count (No/ml)	125	$2.0(10^5)$	200	25	10	100	100	35	100	10	$2.0(10^5)$	9	$0.2(10^5)$	$0.7(10^5)$
Salmonella (D/ND)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	ND	-
Chloride (ppm)	80.4	73.0	68.5	67.5	86.8	81.5	90.7	84.5	158.5	67.5	158.5	9	87.9	27.7
Sulfate (ppm)	87.0	83.0	82.0	79.0	64.0	63.2	73.2	95.2	67.2	63.2	95.2	9	77.1	11.0
Alkalinity (ppm $CaCO_3$)	211	218	179	180.5	152.8	215.8	172.0	127.8	130.0	127.8	218	9	176.3	34.6
$CaCO_3$ Stability (ppm $CaCO_3$)	-3.5	0	-1	0	+5.7	+0.3	+0.2	+4.4	-2.7	0	5.7	9	0.6	-
Sodium (ppm)	78	72.7	97.5	93.2	200	107	52.5	96	101	52.5	200	9	99.8	41.2
Dissolved Solids (ppm)	549.0	434.0	505.0	477.5	529.5	513.0	502.5	535.0	608.0	434.0	549.0	9	517	48.2
Nitrate NO_3-N (ppm)	1.7	ND	4.5	6.0	7.4	0.7	12.4	25	0.7	ND	25.0	8	6.5	-
Nitrite NO_2-N (ppm)	ND	ND	ND	0.06	ND	ND	0.48	ND	0.32	ND	0.48	5	0.10	-
Ammonia N (ppm)	2.00	8.60	5.50	4.80	0.44	0.26	0.04	0.02	21.8	0.02	21.8	9	4.83	7.04
TKN (ppm)	11.5	10.05	6.33	5.19	0.86	58.9	3.05	1.30	23.1	0.86	58.9	9	13.4	18.4
COD (ppm)	ND	37.2	15.2	14.3	11.5	17.0	15.9	7.7	19.7	ND	37.2	9	15.9	-
TOC (ppm)	1.0	35.1	17.2	26.1	8.3	6.8	5.3	4.1	7.3	1.0	35.1	9	12.4	11.5
CN (ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.005	-
Phenol (ppb)	ND	ND	7.5	5.0	ND	ND	ND	ND	8.8	ND	8.8	9	5.7	-
Fluoride (ppm)	1.30	1.10	0.53	0.41	0.42	0.66	0.56	0.48	0.60	0.41	1.30	9	0.67	0.31
CCE (ppm)	0.3	1.0	1.8	0.2	0.2	2.9	-	2.6	0.1	0.1	2.9	8	1.2	1.1
CAE (ppm)	ND	0.3	1.8	2.0	3.1	11.3	1.2	7.8	2.5	ND	11.3	8	3.3	-
Chlorine Demand (ppm)	1.8	#	2.6	5.8	#	3.4	#	#	#	1.8	5.8	4	3.4	1.7
Chlorine, Residual (ppm)	9.2	#	12.4	9.2	#	11.6	2.4	9.72	2.5	2.4	12.4	7	8.1	4.07
As (ppb)	ND	ND	39	43	39	43	24	ND	ND	ND	43	9	25	-
Ba (ppb)	300	ND	ND	ND	ND	ND	47	100	ND	ND	300	9	67	-
b (ppb)	8000	ND	ND	ND	ND	ND	ND	ND	ND	ND	8000	9	5300	-
Cd (ppb)	ND	ND	ND	4.2	1.0	1.0	ND	7.0	ND	ND	7	9	2	-
Cr (ppb)	124	39	10	8	5	49	30	6	77	5	124	9	39	40
Cu (ppb)	21	53	41	48	37	56	40	80	55	21	80	9	48	16
Fe (ppb)	322	172	ND	552	157	28	90	55	45	ND	552	9	158	-
Pb (ppb)	15	8	ND	ND	ND	ND	ND	ND	3	ND	15	9	6	-
Mn (ppb)	65	15	7	5	5	8	10	2	9	2	65	9	14	20
Hg (ppb)	18	5	ND	ND	ND	ND	1.7	1.61	0.31	ND	18	9	3.1	-
Se (ppb)	ND	ND	105	129	250	280	230	ND	ND	ND	280	9	115	-
Ag (ppb)	ND	ND	ND	ND	1.5	1.5	ND	1.6	ND	ND	1.6	9	1.2	0.65
Zn (ppb)	300	15	67	88	17	27	130	62	54	15	300	9	84	89
Aldrin (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.005	-
Dieldrin (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.009	-
Endrin (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.014	-
Heptachlor (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.006	-
Lindane (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.004	-
DDT (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.0016	-
Chlorodane (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.017	-
Methoxychlor (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.046	-
2,4-D (ppb)	ND	0.093	0.078	ND	0.333	0.237	ND	ND	ND	ND	0.333	9	0.095	-
2,4,5-TP (ppb)	ND	ND	ND	ND	0.345	0.289	ND	ND	ND	ND	0.345	9	0.083	-
2,4,5-T (ppb)	ND	ND	ND	ND	ND	<0.029	ND	ND	ND	ND	<0.029	9	0.013	-
Diazinon (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.011	-

(continued)

TABLE A-1. ANALYTICAL DATA, POMONA PROCESS ONE (continued)

	1 9/20/74	2 10/2/74	3 10/7/74	4 10/21/74	5 11/11/74	6 12/5/74	7 4/24/76	8 9/16/75	9 11/7/75	Low	High	n	$\bar{x}$	σ
Ethyl Parathion (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.012	-
Imidan (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.078	-
Malathion (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.015	-
Methyl Azinphos (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.108	-
Methyl Parathion (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.018	-
Carbaramtes (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	-	-
Turbidity (NTU)	0-5*	0-5*	0.36	0.39	0.30	0.73	1.8	1.08	1.58	0.30	1.58	7	0.89	0.61
Odor (No.)	4.0	3.47	4.6	2.0	16.0	5.28	1.6	1.7	5.28	1.6	16.0	9	4.88	4.42
Taste (No.)	§	3.13	4.0	1.32	6.06	4.59	1.5	2.3	5.28	1.32	6.06	8	3.52	1.75
Suspended Solids (ppm)	ND	ND	ND	ND	ND	ND	0.5	3.0	3.0	ND	3.0	9	0.8	-
Color(Pt-Co units)	ND	ND	ND	ND	ND	7	3	3	4	ND	7	9	2	-
Temperature (°C)	25	‡	24	24	‡	23.5	‡	‡	28	23.5	28	5	24.9	1.82
pH	6.9	‡	7.1	7.2	‡	7.4	‡	‡	7.2	6.9	7.4	5	7.2	0.2
Conductivity (Micro mhos)	863	662	800	760	814	907	843	908	891	662	908	9	828	80
Foaming (sec.)	2.0	3.5	2.4	11.1	79.8	261.8	80.4	24.3	105	2	261.8	9	63.4	84.4
Gross α (pCi/l)	<1.3	<1.4	<1.0	<1.0	<0.7	<1.2	<0.5	<6.8	<4.3	<0.5	<6.8	9	2.0	-
Gross β (pCi/l)	<3.4	<5.3	<22.5	<13.5	<7.3	<21.4	<3.7	<29.4	<28.4	<3.4	<29.4	9	15.0	-
Tritium (pCi/l)	530±310	590±280	450±260	350±250	200±350	940±260	640±250	<400	<390	200	940	7	528	235

ND - Not detected

* ppm SiO_2

‡ On-site determination; data not supplied to GSRI

§ Data not available

TABLE A-2. ANALYTICAL DATA, POMONA PROCESS TWO

	1 9/25/74	2 9/27/74	3 10/9/74	4 10/23/74	5 11/13/74	6 12/6/74	7 9/12/75	8 9/19/75	9 9/24/75	Low	High	n	$\bar{x}$	σ
Total Coliform (No./100 ml)	540	79	130	110	350	180	>2400	2	0	0	>2400	9	421	-
Fecal Coliform (No./100 ml)	6	2	4	8	49	13	>2400	0	0	0	>2400	9	275	-
Total Plate Count (No./ml)	$3.1(10^5)$	$2.4(10^5)$	$0.07(10^5)$	$0.016(10^5)$	$1.5(10^5)$	$1.0(10^5)$	$12.0(10^5)$	$14.0(10^5)$	$35.0(10^5)$	$0.07(10^5)$	$35.0(10^5)$	9	$7.7(10^5)$	$12.0(10^5)$
Salmonella (D/ND)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	ND	-
Chloride (ppm)	67.5	93.3	95.8	96.0	86.2	68.8	85.4	207.4	159.4	67.5	207.4	9	106.6	46.3
Sulfate(ppm)	84.0	86.0	90.5	84.0	67.5	64.2	112.0	90.8	91.6	64.2	112.0	9	85.6	14.0
Alkalinity (ppm)	208.0	214.0	188.0	184.0	146.5	202.9	139.7	126.4	116.8	116.8	214	9	169.5	37.4
$CaCO_3$ Stability(ppm $CaCO_3$)	0	-2	-1.5	+2.5	+0.1	+0.6	-1.1	-2.4	+8.3	0	+8.3	9	0.5	3.3
Sodium(ppm)	78	96	158	124	103	87	94	100	95	78	158	9	103.9	23.8
Dissolved Solids(ppm)	496	561	545	538	504	337	627	641	356	337	641	9	511.7	105.7
Nitrate NO_3 -N (ppm)	ND	2.7	2.7	3.5	1.3	1.4	23	19	17	ND	23	9	7.9	-
Nitrite NO_2 -N (ppm)	ND	ND	1.0	ND	ND	0.13	1.6	2.4	1.4	ND	2.4	9	0.73	-
Ammonia N (ppm)	9.0	11.7	7.0	7.0	1.58	7.0	2.34	8.2	12.1	1.58	12.1	9	7.32	3.6
TKN(ppm)	10.7	12.6	0.95	1.05	2.78	32.1	0.55	6.28	12.03	0.55	32.1	9	8.77	10.02
COD(ppm)	3.8	3.8	12.5	10.2	11.7	12.7	73.7	6.0	8.6	3.8	73.7	9	15.9	22.0
TOC(ppm)	ND	4.3	29.0	26.3	11.0	3.4	12.7	5.3	5.8	ND	29.0	9	11.0	-
CN(ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.005	-
Phenol(ppb)	ND	ND	6.5	ND	5.0	ND	ND	ND	19.8	ND	19.8	9	4.6	-
Fluoride (ppm)	0.92	1.05	1.00	1.05	0.58	0.52	0.61	0.71	0.70	0.52	1.05	9	.79	.21
CCE(ppm)	0.2	§	0.7	§	0.4	1.6	0.1	0.1	0.3	0.1	1.8	8	.5	.6
CAE(ppm)	0.9	§	2.9	§	2.8	4.7	6.2	1.8	0.9	0.9	6.2	8	2.9	1.8
Chlorine Demand(ppm)	1.4	3.8	9.4	5.8	9.4	3.8	#	#	#	1.4	9.4	6	5.6	3.3
Chlorine Residual(ppm)	13.6	11.2	5.6	9.2	5.6	11.2	7.3	5.9	0.8	0.8	13.6	9	7.8	3.9
As(ppb)	ND	ND	47	31	67	86	ND	ND	ND	ND	86	9	31.2	-
Ba(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	25	-
B(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	500	-
Cd(ppb)	ND	ND	ND	ND	ND	ND	2.7	ND	ND	ND	2.7	9	1.2	-
Cr(ppb)	31	29	33	23	17	23	6	3	ND	ND	33	9	18.4	-
Cu(ppb)	11	22	28	27	21	15	44	71	117	11	117	9	41	-
Fe(ppb)	201	210	6	3309	20	22	28	40	54	6	3309	9	432.2	1082
Pb(ppb)	15	18	ND	ND	ND	ND	ND	ND	ND	ND	18	9	4.4	-
Mn(ppb)	6	7	16	11	4	3	7	5	11	3	16	9	7.8	4.1
Hg(ppb)	ND	ND	ND	ND	ND	0.75	1.71	ND	ND	ND	1.71	9	0.51	-
Se(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	10	-
Ag(ppb)	5	5	ND	ND	ND	ND	ND	ND	ND	ND	5	9	2	-
Zn(ppb)	48	91	131	96	13	16	44	31	56	13	131	9	58.4	39.8
Aldrin(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.005	-
Dieldrin(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.009	-
Endrin(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.014	-
Heptachlor(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.006	-
Lindane(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.004	-
DDT(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.0016	-
Chlorodane(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.017	-
Methoxychlor(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.046	-
2,4-D(ppb)	ND	ND	ND	ND	0.123	<0.063	ND	ND	ND	ND	0.123	9	0.023	-
2,4,5-TP(ppb)	ND	ND	ND	ND	<0.023	<0.024	ND	ND	ND	ND	<0.024	9	0.019	-
2,4,5-T(ppb)	ND	ND	ND	ND	0.081	ND	ND	ND	ND	ND	0.081	9	0.011	-
Diazinon(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.011	-

(continued)

TABLE A-2. ANALYTICAL DATA, POMONA PROCESS TWO (continued)

Ethyl Parathion(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.012	-
Imidan(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.078	-
Malathion(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.015	-
Methyl Azinphos(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.108	-
Methyl Parathion(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.018	-
Carbamates(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	-	-
Turbidity(NTU)	0-5 *	0-5 *	0.34	0.25	0.4	0.34	0.92	0.72	1.63	0.25	1.63	7	.66	.49
Odor(No)	<1.00	<1.14	<1.32	1.10	1.52	5.72	2.60	1.70	4.59	<1	4.59	7	2.30	-
Taste(No.)	<1.26	<1.74	<1.32	2.30	2.00	§	3.03	2.3	§	<1	3.03	6	2.06	-
Suspended Solids(ppm)	13	13	ND	ND	ND	ND	6	7	1	ND	13	9	4	-
Color(Pt-Co Units)	ND	ND	ND	ND	5	5	4	3	3	ND	5	9	3	-
Temperature(°C)	24	25	24	25.5	24	23.5	#	27	31	23.5	31	8	25.5	2.5
pH	7.25	7.10	7.05	6.90	7.20	7.40	#	7.10	7.60	6.90	7.60	8	7.20	.22
Conductivity(Micro mhos)	808	940	910	860	800	810	900	950	1030	800	1030	9	890	79
Foaming(sec.)	2.3	2.3	1.5	1.8	2.8	48.8	10.0	20.0	20.3	1.5	48.8	9	12.2	15.7
Gross α(pCi/l)	<2.0	<2.8	<1.4	<1.0	<0.6	<2.0	<5.3	<5.6	<5.5	<0.6	<5.6	9	2.9	-
Gross β(pCi/l)	<8.5	<6.2	<9.3	<17.4	<3.7	<25.1	<27.8	<17.9	<24.4	<3.7	<27.8	9	15.6	-
Tritium(pCi/l)	640±280	300±250	650±260	150±250	67±350	810±280	<400	410±390	395±390	67	810	8	428	258

ND - Not detected

* ppm SiO_2

§ Data not available

On-site determination, data not supplied to GSRI

TABLE A-3. ANALYTICAL DATA, POMONA PROCESS THREE

	1 9/23/75	2 9/25/75	3 10/24/75	4 11/6/75	5 11/9/75	6 2/13/76	7 2/23/76	8 3/5/76	9 3/17/76	n	$\bar{x}$	σ	Low	High
Total Coliform (No/100 ml)	460	2	0	17	>2,400	13	>2,400	230	14	9	615	1023	0	>2,400
Fecal Coliform (no/100 ml)	0	0	0	11	>2,400	0	540	50	0	9	333	794	0	>2,400
Plate Count (No./ml)	$3.4(10^6)$	$1.7(10^6)$	$0.4(10^6)$	$0.3(10^6)$	$1.2(10^6)$	$0.1(10^6)$	$1.7(10^6)$	$3.0(10^6)$	$0.5(10^6)$	9	$1.4(10^6)$	$1.2(10^6)$	$0.1(10^6)$	$3.4\ 10^6$
Salmonella (D/ND)	ND	ND	ND	ND	$+C_1$	ND	$+C_1$	ND	ND	9	ND	-	ND	$+C_1$
Chloride (ppm)	102.4	112.4	97.3	84.6	109.5	81.9	93.8	113.6	91.8	9	98.6	11.7	81.9	113.6
Sulfate (ppm)	96.8	94.0	99.2	80.0	124.4	82.8	77.8	74.0	72.8	9	89	15	73	120
Alkalinity (ppm CaCO$_3$)	145.1	112.8	141.8	134.3	64.6	247.1	228.7	124.6	158.6	9	150.8	56.3	64.6	247.1
CaCO$_3$ Stability (ppm CaCO$_3$)	+9.8	+14.3	+3.2	-4.3	-0.1	-7.52	-6.3	+3.88	-4.49	9	1.94	7.31	-0.1	+14.3
Sodium (ppm)	98.0	97.0	116.7	63.0	104.1	89.3	112.0	58.0	281.2	9	118.8	68.5	58.0	281.2
Dissolved Soilds (ppm)	582	597	733	598	618	477	501	516	514	9	571	79	477	733
Nitrate NO$_3$-N (ppm)	16	20	0.9	0.7	0.8	5.0	8.0	42.9	36.8	9	14.7	15.9	0.7	42.9
Nitrite NO$_2$-N (ppm)	ND	0.03	0.02	0.29	0.17	3.18	5.9	0.03	0.15	8	1.1	-	ND	5.9
NH$_3$-N (ppm)	5.80	2.55	12.5	1.14	19.8	17.2	4.70	3.40	2.10	9	7.69	7.00	1.14	19.8
TKN (ppm)	4.85	0.67	5.49	5.84	41.4	33.7	18.1	5.34	2.39	9	13.09	14.83	0.67	41.4
COD (ppm)	7.6	11.5	13.4	19.4	14.1	23.9	32.5	18.5	20.4	9	17.9	7.4	7.6	32.5
TOC (ppm)	5.8	30.5	5.9	6.2	7.0	9.7	15.7	10.5	14.6	9	11.8	7.94	5.8	30.5
CN (ppm)	0.01	ND	ND	ND	ND	ND	ND	ND	ND	9	0.006	-	ND	0.01
Phenol (ppb)	ND	ND	ND	5.5	ND	ND	ND	10.2	12.8	9	6.5	-	ND	12.8
CCE (ppm)	0.3	2.9	0.1	0.1	0.3	0.4	0.6	0.9	1.4	9	0.8	0.9	0.1	2.9
CAE (ppm)	2.8	5.3	2.7	2.7	2.4	2.0	1.6	3.0	4.3	9	3.0	1.2	1.6	5.3
Chlorine Demand (ppm)	#	#	#	#	#	#	#	#	#	#	#	#	#	#
Chlorine Residual (ppm)	0.9	0.7	0.5	0.3	0.5	0.5	0.5	0.9	1	9	0.644	0.240	0.3	1
As (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	10	-	ND	ND
Ba (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	25	-	ND	ND
B (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	500	-	ND	ND
Cd (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	3	9	1.2	-	ND	3
Cr (ppb)	33	46	48	55	49	59	127	74	64	9	62	27	33	127
Cu (ppb)	49	68	67	44	43	42	66	48	22	9	50	15	22	68
F (ppm)	0.68	0.65	0.70	0.66	0.82	0.73	0.82	0.78	0.71	9	0.73	0.06	0.65	0.82
Fe (ppb)	83	78	45	93	45	48	40	41	46	9	58	21	41	93
Pb (ppb)	7	ND	7	12	ND	7	7	4	17	9	7	-	ND	17
Mn (ppb)	6	8	16	9	9	10	8	7	ND	9	7	-	ND	16
Hg (ppb)	0.73	ND	ND	1.35	0.29	1.50	ND	0.54	0.32	9	0.63	0.52	ND	1.50
Se (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	10	-	ND	ND
Ag (ppb)	40.3	40.4	43.8	41.3	40.3	50.7	52.0	40.9	40.1	9	43.3	4.7	40.1	52.0
Zn (ppb)	30	33	94	52	42	87	89	52	112	9	66	30	30	112
Aldrin (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.005	-	ND	ND
Dieldrin (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.009	-	ND	ND
Endrin (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.014	-	ND	ND
Heptachlor (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.006	-	ND	ND
Lindane (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.004	-	ND	ND
DDT (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.0016	-	ND	ND
Chlorodane (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.017	-	ND	ND
Methoxychlor (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.046	-	ND	ND
2,4-D (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.023	-	ND	ND
2,4,5-TP (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.016	-	ND	ND
2,4,5-T (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.011	-	ND	ND
Diazinon (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.011	-	ND	ND

(continued)

TABLE A-3. ANALYTICAL DATA, POMONA PROCESS THREE (continued)

	1 9/23/75	2 9/25/75	3 10/24/75	4 11/6/75	5 11/9/75	6 2/13/76	7 2/23/76	8 3/5/76	9 3/17/26	n	$\bar{x}$	σ	Low	High
Ethyl Parathion (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.012	-	ND	ND
Imidan (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.078	-	ND	ND
Malathion (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.015	-	ND	ND
Methyl Azinphos (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.108	-	ND	ND
Methyl Parathion (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	0.018	-	ND	ND
Carbamates (ppb)*	ND	ND	ND	ND	ND	ND	ND	ND	ND	9	-	-	ND	ND
Turbidity (NTU)	1.2	1.15	0.95	0.97	0.99	0.99	2.10	0.94	1.10		1.15	0.4	0.94	2.10
Odor (No.)	4.00	2.30	3.03	2.29	§	<9.19	12.13	4.00	2.63	8	6.58	6.71	2.30	13.9
Taste (No.)	3.48	3.50	6.06	≠	≠	10.56	≠	≠	≠	4	5.9	3.33	3.48	6.06
Suspended Solids (ppm)	2	6	4	8	2	4	1	3	1	9	3	2	1	8
Temperature (°C)	#	#	#	#	#	#	#	#	#	#	#	#	#	#
pH	7.7	7.8	7.1	7.6	7.3	§	7.7	7.3	7.1	8	7.5	0.28	7.1	7.8
Conduc tivity (Micro mhos)	960.0	920.0	954.5	891.8	958.8	918.0	938.4	979.2	910.0	9	936.9	28.6	891.8	979.2
Foaming (sec.)	14.2	27.4	23.4	50	66	7.6	22.5	6.4	8.8	9	25.1	20.5	6.4	66
Gross α (pCi/1)	<8.3	<4.8	<8.6	<5.9	<2.4	<4.7	<8.7	<4.0	<5.8	9	5.9	-	2.4	8.7
Gross β (pCi/1)	<26.7	<12.1	<22.5	<10.4	<22.6	<29.7	<17.3	<29.2	<26.1	9	21.8	-	10.4	29.7
Tritium (pCi/1)	16±390	199±390	710±410	160±395	29±390	107±387	81±386	160±387	<400	8	183	223	16	710

* Carbaryl, fluometuron, and carbofuran

§ Data not available

≠ Analysis not possible - high fecal coliform count

# On-site determination; data not supplied to GSRI

ND - Not detected

TABLE A-4. ANALYTICAL DATA, LAKE TAHOE

	1 9/26/74	2 10/8/74	3 10/22/74	4 11/6/74	5 11/21/74	6 12/7/74	7 1/16/75	8 2/13/75
Total Coliform (No/100 ml)	2	0	46	49	0	0	5	2
Fecal Coliform (No/100 ml)	0	0	14	0	0	0	0	0
Total Plate Count (No./ml)	$6.5(10^4)$	$85.0(10^4)$	$80.0(10^4)$	$80.0(10^4)$	$20.0(10^4)$	$0.005(10^4)$	$4.5(10^4)$	$30.0(10^4)$
Salmonella (D/ND)	ND	ND	ND	ND	ND	ND	ND	ND
Chloride (ppm)	35.2	48.1	41.0	29.9	33.3	36.1	0.3	57.1
Sulfate (ppm)	26.0	32.0	29.0	27.0	22.3	25.7	27.8	33.3
Alkalinity (ppm $CaCO_3$)	205.0	193.5	188.0	192.0	200.2	278.8	328	236.2
$CaCO_3$ Stability (ppm $CaCO_3$)	-10.0	+2.5	+20.0	+26.5	+2.3	-1.6	-4.9	-0.2
Sodium (ppm)	41.0	50.7	49.0	47.5	47.3	44.7	37.9	238.1
Dissolved Solids (ppm)	293.0	282.0	308.0	306.1	315.0	387.0	416.5	505
Nitrate NO_3-N (ppm)	ND	1.6	ND	ND	0.7	0.7	5.5	1.71
Nitrite NO_2-N (ppm)	ND	3.30	0.15	0.55	0.33	0.20	ND	ND
Ammonia N (ppm)	19.5	17.0	24.0	10.3	10.3	10.3	24.0	18.5
TKN (ppm)	21.2	19.4	21.2	21.2	0.81	27.3	0.79	29.7
As (ppb)	14	110	100	39	36	43	21	47
Ba (ppb)	ND	ND	ND	ND	ND	ND	ND	ND
B (ppb)	ND	ND	ND	ND	ND	ND	ND	ND
Cd (ppb)	ND	20.8	2.1	ND	1	1.0	ND	ND
Cr (ppb)	14	ND	ND	ND	2.5	2.5	ND	ND
Cu (ppb)	22	39	42	26	18	18	19	32
F (ppm)	0.37	0.31	0.22	0.23	0.28	0.37	0.22	0.21
Fe (ppb)	292	1000	377	556	109	52	111	43
Pb (ppb)	9	ND	ND	ND	ND	ND	ND	ND
Mn (ppb)	8	5	5	5	5	7	4	14
Hg (ppb)	ND	ND	ND	ND	ND	ND	0.66	ND
Se (ppb)	ND	350	258	57	210	52	150	200
Ag (ppb)	5	ND	ND	ND	ND	ND	ND	ND
Zn (ppb)	134	794	481	280	107	46	ND	202
COD (ppm)	8.3	ND	1.6	5.7	5.1	3.5	19.1	15.6
TOC (ppm)	17.7	11.3	30.5	11.1	7.2	ND	12.5	6.4
CCE (ppm)	0.6	§	§	0.5	0.3	0.7	§	1.6
CAE (ppm)	2.0	§	§	1.5	1.1	3.1	0.2	4.1

(continued)

TABLE A-4. ANALYTICAL DATA, LAKE TAHOE (continued)

	9 2/21/75	10 3/12/75	11 4/8/75	12 6/18/75	13 7/2/75	Low	High	n	$\bar{x}$	σ
Total Coliform (No/100 ml)	220	4	0	0	§	0	220	12	27.33	63.25
Fecal Coliform (No/100 ml)	0	2	0	0	§	0	14	12	1.33	4.03
Total Plate Count (No./ml)	3.0(10^4)	18.0(10^4)	5.0(10^4)	35.0(10^4)	§	0.005(10^4)	80.0(10^4)	12	35.5(10^4)	33.1(10^4)
Salmonella (D/ND)	ND	ND	ND	ND	ND	ND		13	ND	-
Chloride (ppm)	43	109.4	115.9	114.0	186.2	0.3	115.9	13	65.34	50.99
Sulfate (ppm)	33.0	25.3	28.8	26.9	28.4	22.3	33.3	13	28.11	3.20
Alkalinity (ppm $CaCO_3$)	254.2	152.5	148.0	155.7	39.7	39.7	328	13	197.8	70.51
$CaCO_3$ Stability (ppm $CaCO_3$)	-0.08	+3.7	-0.9	-3.2	+20.5	-0.08	+26.5	13	3.58	11.54
Sodium (ppm)	34.7	37.3	30.6	43.0	44.0	30.6	238.1	12	42.3	6.2
Dissolved Solids (ppm)	414.0	470.5	415.5	445.0	474	282	505	13	387.0	77.50
Nitrate NO_3-N (ppm)	0.50	3.70	0.60	10.00	2.20	ND	10	13	1.65	-
Nitrite NO_3-N (ppm)	ND	ND	ND	4.0	0.3	ND	4.0	13	10	-
Ammonia N (ppm)	21.0	10.3	13.8	15.0	4.97	4.97	24.0	13	15.3	5.94
TKN (ppm)	27.5	15.2	5.78	17.5	5.82	0.79	27.5	13	16.41	10.04
As (ppb)	ND	ND	ND	ND	ND	ND	100	13	27.8	-
Ba (ppb)	ND	ND	ND	ND	ND	ND	ND	13	25	-
B (ppb)	ND	ND	ND	ND	ND	ND	ND	13	500	-
Cd (ppb)	ND	ND	ND	2	ND	ND	20.8	13	2.7	-
Cr (ppb)	3	ND	ND	ND	ND	ND	14	13	2.4	-
Cu (ppb)	56	120	90	70	110	18	120	13	50.9	35.8
F (ppm)	0.28	0.19	0.21	0.11	0.07	0.07	0.37	13	0.24	0.09
Fe (ppb)	66	210	150	140	130	43	1000	13	248.85	268.90
Pb (ppb)	ND	ND	ND	40	ND	ND	40	13	5	-
Mn (ppb)	12	20	20	20	20	4	20	13	11.5	6.78
Hg (ppb)	ND	ND	ND	0.99	0.49	ND	0.99	13	0.39	-
Se (ppb)	160	70	190	100	170	ND	350	13	152	-
Ag (ppb)	ND	ND	ND	ND	2	ND	2	13	1	-
Zn (ppb)	58	2090	2650	3610	2700	46	3610	13	1010	-
COD (ppb)	26.1	8.2	7.5	6.1	5.2	1.6	26.1	13	9.0	-
TOC (ppm)	16.5	2.5	3.6	5.8	4.3	ND	30.5	13	10.0	-
CCE (ppm)	0.5	§	§	1.6	0.8	0.48	1.6	8	0.8	0.5
CAE (ppm)	1.0	2.1	2.7	2.2	5.1	0.2	4.1	11	2.3	1.4
Chlorine Demand (ppm)	#	#	#	#	#	-	-	-	-	-
Chlorine Residual (ppm)	#	#	#	#	#	-	-	-	-	-

(continued)

TABLE A-4. ANALYTICAL DATA, LAKE TAHOE (continued)

	1 9/27/74	2 10/8/74	3 10/22/74	4 11/6/74	5 11/21/74	6 12/7/74	7 1/16/75	8 2/13/75
Chlorine Demand (ppm)	#	#	#	#	#	#	#	#
Chlorine Residual (ppm)	#	#	#	#	#	#	#	#
CN (ppm)	0.03	0.02	ND	0.03	ND	ND	ND	ND
Phenols (ppb)	2.0	7.0	ND	ND	5.0	ND	6.4	§
Aldrin (ppb)	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin (ppb)	ND	ND	ND	ND	ND	ND	ND	ND
Endrin (ppb)	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor (ppb)	ND	ND	ND	ND	ND	ND	ND	ND
Lindane (ppb)	ND	ND	ND	ND	ND	ND	ND	ND
DDT (ppb)	ND	ND	ND	ND	ND	ND	ND	ND
Chlorodane (ppb)	ND	ND	ND	ND	ND	ND	ND	ND
Methoxychlor (ppb)	ND	ND	ND	ND	ND	ND	ND	ND
2,4-D (ppb)	ND	ND	0.149	ND	0.551	ND	ND	ND
2,4,5-TP (ppb)	ND	ND	ND	ND	0.375	ND	ND	ND
2,4,5-T (ppb)	ND	ND	ND	ND	<0.024	ND	ND	ND
Diazinon (ppb)	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl Parathion (ppb)	ND	ND	ND	ND	ND	ND	ND	ND
Imidan (ppb)	ND	ND	ND	ND	ND	ND	ND	ND
Malathion (ppb)	ND	ND	ND	ND	ND	ND	ND	ND
Methyl Azinphos (ppb)	ND	ND	ND	ND	ND	ND	ND	ND
Methyl Parathion (ppb)	ND	ND	ND	ND	ND	ND	ND	ND
Carbamates (ppb)	ND	ND	ND	ND	ND	ND	ND	ND
Turbidity (NTU)	0-5	ND	0.96	0.94	2.20	1.60	1.04	§
Odor (No.)	2.52	2.00	<1.15	<1.15	<1.52	1.15	1.32	<1.15
Taste (No.)	2.00	1.41	2.64	<1.15	1.52	1.00	2.64	ND
Color (Pt-Co units)	ND	ND	ND	4	5	5	3	1
Suspended Solids (ppm)	ND	2.5	4.0	4.5	ND	ND	ND	ND
Temperature (°C)	#	#	#	#	#	#	#	#
pH	7.55	7.2	#	#	#	#	#	#
Conductivity (Micro mhos)	575	590.0	550.0	494	567	728	813.2	735.0
Foaming (sec.)	17.	1.6	1.7	0.9	1.5	1.3	1.6	3.59
Gross β (pCi/l)	<7.9	<9.3	<3.4	<4.4	<7.5	<17.0	<8.1	<11.9
Gross α (pCi/l)	<4.4	<1.1	ND	ND	ND	3.1	ND	ND
Tritium (pCi/l)	<250	500 ± 260	700 ± 260	<350	140 ± 340	800 ± 260	847 ± 243	678 ± 237

(continued)

TABLE A-4. ANALYTICAL DATA, LAKE TAHOE (continued)

	9 2/21/75	10 3/13/75	11 4/8/75	12 6/18/75	13 7/2/75	Low	High	n	$\bar{x}$	σ
CN (ppm)	ND	ND	ND	0.02	ND	ND	0.03	13	0.011	-
Phenols (ppb)	9	5.8	9.8	ND		ND	9.8	12	4.4	-
Aldrin (ppb)	ND	ND	ND	ND	ND	ND	ND	13	0.005	-
Dieldrin (ppb)	ND	ND	ND	ND	ND	ND	ND	13	0.009	-
Endrin (ppb)	ND	ND	ND	ND	ND	ND	ND	13	0.014	-
Heptachlor (ppb)	ND	ND	ND	ND	ND	ND	ND	13	0.006	-
Lindane (ppb)	ND	ND	ND	ND	ND	ND	ND	13	0.004	-
DDT (ppb)	ND	ND	ND	ND	ND	ND	ND	13	0.0016	-
Chlorodane (ppb)	ND	ND	ND	ND	ND	ND	ND	13	0.017	-
Methoxychlor (ppb)	ND	ND	ND	ND	ND	ND	ND	13	0.046	-
2,4-D (ppb)	ND	ND	ND	ND	ND	ND	0.551	13	0.075	-
2,4,5-TP (ppb)	ND	ND	ND	ND	ND	ND	0.375	13	0.046	-
2,4,5-T (ppb)	ND	ND	ND	ND	ND	ND	<0.024	13	0.012	-
Diazinon (ppb)	ND	ND	ND	ND	ND	ND	ND	13	0.011	-
Ethyl Parathion (ppb)	ND	ND	ND	ND	ND	ND	ND	13	0.012	-
Imidan (ppb)	ND	ND	ND	ND	ND	ND	ND	13	0.078	-
Malathion (ppb)	ND	ND	ND	ND	ND	ND	ND	13	0.015	-
Methyl Azinphos (ppb)	ND	ND	ND	ND	ND	ND	ND	13	0.108	-
Methyl Parathion (ppb)	ND	ND	ND	ND	ND	ND	ND	13	0.018	-
Carbamates (ppb)	ND	ND	ND	ND	ND	ND	ND	13	-	-
Turbidity (NTU)	1.40	2.40	2.20	1.50	1.48	0.96	2.4	10	1.57	0.53
Odor (No.)	9.18	<1.00	<1.00	1.51	1.74	1.15	9.18	13	2.03	-
Taste (No.)	4.59	<1.15	§	3.48	2.30	ND	4.59	12	2.07	-
Color (Pt-Co units)	7	4	4	3	2	ND	7	13	4	-
Suspended Solids (ppm)	3.5	5.0	4.0	2.5	1.0	ND	5.0	13	2.1	-
Temperature (°C)	#	#	#	#	#	-	-	-	-	-
pH	#	#	#	#	#	-	-	-	-	-
Conductivity (Micro mhos)	752.4	671.0	681.0	780.5	785.5	494	813.2	13	668.8	102.78
Foaming (sec.)	72.5	1.8	1.3	2.3	1.4	0.9	72.5	1	7.17	19.64
Gross β (pCi/1)	<6.0	<7.[illegible]	<3.2	<17.4	<12.7	<3.4	<17.4	13	8.9	-
Gross α (pCi/1)	<1.1	<1.7	ND	<1.2	<2.6	<0.5	<4.4	13	1.6	-
Tritium (pCi/1)	552±240	613±241	613±241	220	140	140	880	13	499	-

§ Data not available

On-site determination; sample not supplied to GSRI

ND - Not detected

TABLE A-5. ANALYTICAL DATA, DALLAS

	1	2	3	4	5	6	7	8	Low	High	n	x̄	σ
	9/5/74	9/13/74	10/4/74	10/16/74	10/20/74	12/9/74	1/24/75	1/29/75					
Total Coliform (No/100 ml)	0	0	0	23	0	23	§	4	0	23	7	7	11
Fecal Coliform (No/100 ml)	0	0	0	23	0	0	§	0	0	23	7	3	9
Total Plate Count (No/ml)	7.3 (10^2)	2.0 (10^2)	30.0 (10^2)	20.0 (10^2)	0.15 (10^2)	0.30 (10^2)	§	0.30 (10^2)	0.15 (10^2)	73.0 (10^2)	7	18.0 (10^2)	27.0 (10^2)
Salmonella (D/ND)	ND	ND	ND	ND	ND	ND	§	ND	ND	ND			
Chloride (ppm)	78.7	75.7	89.3	79.7	62.5	71.5	74.0	53.6	53.6	89.3	8	73.1	11.0
Sulfate (ppm)	85.5	87.0	100.0	90.5	89.5	75.0	113.2	96.4	86	113	8	92.1	11
Alkalinity (ppm $CaCO_3$)	90.7	100.0	133.0	127.0	236.0	257.0	164.9	239.4	90.7	257	8	168.5	66.7
$CaCO_3$ Stability (ppm $CaCO_3$)	+9	+48.5	+18.5	-1	-15	-0.4	+66.3	-0.2	-0.2	+66.3	8	15.8	27.8
Sodium (ppm)	53.0	62.0	78.0	-	89.0	74.0	73.1	57.9	53.0	89.0	7	69.6	12.6
Dissolved Solids (ppm)	356	424	405	461	563	515	484	537	356	563	8	468	70
Nitrate NO_3-N (ppm)	2.7	4.5	6.7	6.5	10.0	0.5	2.9	4.6	0.5	10.0	8	4.8	2.9
Nitrite NO_2-N (ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8	0.01	
Ammonia N (ppm)	0.043	0.10	0.064	0.040	0.080	7.8	2.40	0.031	0.04	2.40	8	1.32	2.74
TKN (ppm)	0.32	0.45	0.36	1.10	0.87	6.8	5.28	0.15	0.15	6.8	8	1.92	2.60
COD (ppm)	15.2	3.8	8.3	0.4	0.4	2.7	3.3	7.9	0.4	15.2	8	5.24	4.99
TOC (ppm)	3.7	0.5	7.4	6.4	18.7	ND	8.6	14.6	ND	18.7	8	7.6	-
CN (ppm)	ND	ND	ND	ND	ND	0.005	ND	ND	ND	ND	8	0.005	-
Phenol (ppb)	ND	ND	7.4	7.5	8.0	11.2	7.0	3.0	ND	11.2	8	6.5	-
Fluoride (ppm)	1.70	1.75	2.00	1.30	1.00	0.80	1.35	0.80	0.80	2.00	8	1.34	0.45
CCE (ppm)	§	§	0.2	1.4	§	0.3	0.2	0.5	0.1	1.4	7	0.4	0.5
CAE (ppm)	§	§	0.4	§	§	4.3	4.3	3.8	0.4	4.3	6	2.8	1.7
CCE (extra)	0.1	0.1	-	-	-	-	-	-	-	-	-	-	-
CAE (extra)	1.1	3.0	-	-	-	-	-	-	-	-	-	-	-
Chlorine Demand (ppm)	#	#	#	#	#	#	#	#	-	-	-	-	-
Chlorine Residual (ppm)	#	#	#	#	#	#	#	#	-	-	-	-	-
As (ppb)	ND	ND	ND	-	53	100	47	21	ND	100	7	36	-
Ba (ppb)	ND	625	250	ND	ND	100	190	ND	ND	625	8	158	-
B (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8	500	-
Cd (ppb)	ND	ND	ND	ND	ND	1	ND	ND	ND	1	8	1	-
Cr (ppb)	8	60	10	ND	3	5	4	4	ND	60	8	12	-
Cu (ppb)	4	17	4	3	5	4	4	7	3	17	8	6	5
Fe (ppb)	225	338	136	49	165	32	28	24	24	338	8	125	114
Pb (ppb)	10	14	7	ND	ND	ND	ND	ND	ND	14	8	5	-
Mn (ppb)	5	6	7	ND	3	4	6	5	ND	7	8	5	-
Hg (ppb)	ND	ND	-	-	ND	ND	-	ND	ND	0.06	6	0.3	-
Se (ppb)	ND	ND	ND	38	69	31	140	150	ND	150	8	57	-
Ag (ppb)	ND	ND	ND	ND	ND	ND	0.66	0.57	ND	4	8	0.53	-
Zn (ppb)	65	87	116	21	11	25	23	6	6	116	8	44	40
Aldrin (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8	0.005	
Dieldrin (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8	0.009	-
Endrin (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8	0.014	-
Heptachlor (ppb)	ND	ND	ND	ND	0.014	ND	ND	ND	ND	0.014	8	0.007	-
Lindane (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8	0.004	-
DDT (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8	0.0016	-
Chlorodane (ppb)	ND	ND	0.109	0.099	ND	ND	ND	ND	ND	0.019	8	0.039	-
Methoxychlor (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8	0.046	-
2,4-D (ppb)	ND	ND	0.062	ND	ND	<0.058	ND	ND	ND	0.062	8	0.032	-
2,4,5-TP (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8	0.016	-
2,4,5-T (ppb)	ND	ND	ND	ND	ND	<0.024	ND	ND	ND	ND	8	0.013	-
Diazinon (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8	0.011	-

(continued)

TABLE A-5. ANALYTICAL DATA, DALLAS (continued)

	1 9/5/74	2 9/13/74	3 10/4/74	4 10/16/74	5 10/20/74	6 12/9/74	7 1/24/75	8 1/29/75	Low	High	n	$\overline{x}$	σ
Ethyl Parathion (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8	0.012	-
Imidan (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8	0.078	-
Malathion (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8	0.015	-
Methyl Azinphos (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8	0.108	-
Methyl Parathion (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8	0.018	-
Carbamates (ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8		-
Turbidity (NTU)	ND*	ND*	ND*	0.35	0.13	0.23	0.71	0.39	ND	ND	8	0.37	0.12
Odor (No.)	<48.60	<5.32	<5.28	<9.19	12.13	4.00	*	8.00	4.0	48.6	7	13.22	-
Taste (No.)	<2.00	1.74	3.03	2.64	4.59	1.99	*	3.03	1.7	4.6	7	2.72	-
Suspended Solids (ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8	0.1	-
Temperature(°C)	#	#	#	#	#	#	#	#	-	-	-	-	-
pH	#	#	#	#	#	#	#	#	-	-	-	-	-
Conductivity (micro mhos)	601	700	600	740	845	906	806	886	600	906	8	761	120
Foaming (sec.)	1.7	2.2	1.9	1.7	2.3	4.4	3.9	4.9	1.7	4.9	8	2.9	1.3
Gross α (pCi/l)	<1.3	<1.0	<3.2	<0.8	<0.8	<1.6	<1.2	<1.1	<1.0	<3.2	8	1.4	-
Gross β (pCi/l)	<6.0	<2.1	<2.7	<19.2	<17.2	<15.8	<14.8	<2.8	<2.1	<19.2	8	10.1	-
Tritium (pCi/l)	750±290	590±310	480±310	350±250	400±260	670±260	730±230	680±237	350	750	8	581	153

ND - Not detected

§ Data not available

On-site determinations; data not supplied to GSRI

* JTU

TABLE A-6. ANALYTICAL DATA, BLUE PLAINS - SYSTEM 1

	1 9/11/74	2 9/20/74	3 9/26/74	Low	High	n	$\overline{x}$	σ
Total Coliform(No./100 ml)	*	2	>2,400	2	>2,400	2	1,200	-
Fecal Coliform(No./100 ml)	*	0	920	0	920	2	460	650
Plate Count(No./ml)	*	240	1.7(10^6)	240	1.7(10^6)	2	0.85(10^6)	1.2(10^6)
Salmonella(D/ND)	*	ND	ND	ND	ND	2	ND	-
Chloride(ppm)	183.4	202.5	177.7	177.7	202.5	3	187.9	13.0
Sulfate(ppm)	76	69	64	64	76	3	70	6
Alkalinity(ppm $CaCO_3$)	15.0	27.7	46.7	15.0	46.7	3	29.8	16.0
$CaCO_3$ Stability(ppm $CaCO_3$)	+57.0	+43.0	+20.8	+20.8	+57.0	3	40.3	18.3
Sodium(ppm)	82	83	71	71	83	3	78.7	6.7
Dissolved Solids(ppm)	524	531	512	512	531	3	522	10
Nitrate NO_3(ppm)	ND	ND	ND	ND	ND	3	0.5	-
Nitrite NO_2(ppm)	ND	ND	ND	ND	ND	3	0.01	-
Ammonia N(ppm)	0.25	0.65	1.75	0.25	1.75	3	0.88	0.77
TKN(ppm)	1.85	2.68	5.2	1.85	5.2	3	3.24	1.74
As(ppb)	37	ND	ND	ND	37	3	19	-
Ba(ppb)	ND	ND	250	ND	250	3	25	-
B(ppb)	ND	ND	ND	ND	ND	3	500	-
Cd(ppb)	ND	ND	ND	ND	ND	3	1	-
Cr(ppb)	10	51	19	10	51	3	27	22
Cu(ppb)	20	13	13	13	20	3	15	4
F(ppm)	1.30	1.10	1.30	1.1	1.3	3	1.23	0.12
Fe(ppb)	255	255	165	165	255	3	225	52
Pb(ppb)	10	51	19	10	51	3	27	22
Mn(ppb)	10	28	8	8	28	3	15	11
Hg(ppb)	ND	ND	ND	ND	ND	3	0.3	-
Se(ppb)	ND	ND	ND	ND	ND	3	10	-
Ag(ppb)	3	6	4	3	6	3	4.33	1.58
Zn(ppb)	86	64	28	28	86	3	59	29
COD(ppm)	*	30.1	30.1	-	-	2	30.1	0.0
TOC(ppm)	*	11.3	12.3	-	-	2	11.8	0.7
CCE(ppm)	§	1.1	1.5	-	-	2	1.3	0.3
CAE(ppm)	§	0.3	2.4	-	-	3	1.3	1.4
Chlorine Demand(ppm)	#	#	#	-	-	-	-	-
Chlorine Residual(ppm)	#	#	#	-	-	-	-	-

(continued)

TABLE A-6. ANALYTICAL DATA, BLUE PLAINS-SYSTEM 1 (continued)

	1 9/11/74	2 9/20/74	3 9/26/74	Low	High	n	$\bar{x}$	σ
CN(ppm)	0.03	0.06	0.04	0.03	0.06	3	0.043	0.015
Phenols(ppb)	*	ND	ND	ND	ND	2	5	-
Aldrin(ppb)	*	ND	ND	ND	ND	2	0.005	-
Dieldrin(ppb)	*	ND	ND	ND	ND	2	0.009	-
Endrin(ppb)	*	ND	ND	ND	ND	2	0.014	-
Heptachlor(ppb)	*	ND	ND	ND	ND	2	0.006	-
Lindane(ppb)	*	ND	ND	ND	ND	2	0.004	-
DDT (ppb)	*	ND	ND	ND	ND	2	0.0016	-
Chlorodane(ppb)	*	ND	ND	ND	ND	2	0.017	-
Methoxychlor(ppb)	*	ND	ND	ND	ND	2	0.046	-
2,4-D(ppb)	*	ND	ND	ND	ND	2	0.023	-
2,4,5-TP(ppb)	*	ND	ND	ND	ND	2	0.016	-
2,4,5-T(ppb)	*	ND	ND	ND	ND	2	0.011	-
Diazinon(ppb)	*	ND	ND	ND	ND	2	0.011	-
Ethyl Parathion(ppb)	*	ND	ND	ND	ND	2	0.012	-
Imidan(ppb)	*	ND	ND	ND	ND	2	0.078	-
Malathion(ppb)	*	ND	ND	ND	ND	2	0.015	-
Methyl Azinphos(ppb)	*	ND	ND	ND	ND	2	0.108	-
Methyl Parathion(ppb)	*	ND	ND	ND	ND	2	0.018	-
Carbamates(ppb)	*	ND	ND	ND	ND	2	-	-
Turbidity(JTU)	ND	ND	0 - 5 ≠	ND	ND	3	5	-
Odor(No.)	*	7	10.56	7	10.56	2	8.8	1.8
Taste(No.)	*	-	-	-	-	-	-	-
Color(Pt-Co units)	ND	ND	ND	ND	ND	3	2	-
Suspended Solids(ppb)	ND	13.0	5.0	ND	13.0	3	6	-
Temperature(°C)	#	#	#	-	-	-	-	-
pH	#	#	#	-	-	-	-	-
Conductivity(Micro mhos)	860	880	825	825	880	3	855	28
Foaming(Sec (3))	2.3	3.0	2.9	2.3	30	3	2.7	0.4
Gross Beta(pCi/l)	<7.6	<5.9	<5.2	<5.2	<7.6	3	6.2	
Gross Alpha(pCi/l)	<0.4	<2.5	<1.4	<0.4	<2.5	3	1.4	
Tritium(pCi/l)	300±250	100±250	150±250	100	300	3	183	104

* Glass container broke in shipping

§ Data not available

# On-site determination; data not supplied to GSRI.

≠ ppm SiO_2

TABLE A-7. ANALYTICAL DATA, BLUE PLAINS- SYSTEM 2

	4 6/13/75	5 7/9/75	6 8/14/75	7 8/24/75	8 9/17/75	9 9/23/75	Low	High	n	$\bar{x}$	σ
Total Coliform(No./100 ml)	2	11	33	0	2	0	0	33	6	8	12.9
Fecal Coliform(No./100 ml)	0	0	0	0	0	0	0	0	6	0	-
Total Plate Count(No/ml)	8(10^5)	200	4(10^5)	100	4(10^5)	35	35	8(10^5)	6	2.7(10^5)	3.3(10^5)
Salmonella(D/ND)	ND	ND	ND	ND	ND	ND	ND	ND	6	ND	-
Chloride (ppm)	70.5	69.1	73.3	64.0	71.9	47.9	64	73.3	6	66.1	9.48
Sulfate (ppm)	44.0	45.7	52.4	50.8	52.4	48.4	44.0	52.4	6	49.0	3.54
Alkalinity (ppm)	100.6	85.9	67.1	75.5	77.1	84.6	67.1	100.6	6	81.8	11.45
$CaCO_3$ Stability(ppm $CaCO_3$)	-1.1	+2.2	+7.2	+3.5	+3.3	+8.6	-1.1	+8.6	6	3.95	3.50
Sodium(ppm)	38	34	39	33	37	34	33	39	6	31	10.87
Dissolved Solids(ppm)	342.0	322	348	339	337	344	322	348	6	339	9.03
Nitrate NO_3 (ppm)	11	5.0	0.18	0.65	0.25	0.34	0.18	11	6	2.90	4.38
Nitrite NO_2(ppm)	0.7	ND	ND	ND	ND	ND	ND	0.7	6	0.1	-
Ammonia N(ppm)	0.042	0.078	0.38	0.04	0.028	0.029	0.028	0.38	6	0.100	0.139
TKN(ppm)	0.86	1.97	0.70	1.33	1.75	1.96	0.70	1.97	6	1.43	0.56
COD(ppm)	9.2	9.1	16.0	7.3	15.5	14.1	7.3	16.0	6	11.9	3.8
TOC(ppm)	5.0	6.5	12.8	8.9	12.6	6.9	5.0	12.8	6	8.8	3.3
CN(ppm)	ND	ND	ND	ND	ND	ND	ND	ND	6	0.005	-
Phenol ppb	ND	ND	ND	ND	ND	19.8	ND	19.8	6	7.5	-
Fluoride (ppm)	0.79	0.74	0.86	0.72	0.80	0.86	0.72	0.86	6	0.745	0.058
CCE(ppm)	ND	0.1	0.1	0.02	0.1	0.1	ND	0.13	5	0.068	0.055
CAE(ppm)	2.1	2.3	3.2	1.3	1.3	1.9	1.3	3.2	6	1.98	0.65
Chlorine Demand(ppm)	#	#	#	#	#	#	-	-	-	-	-
Chlorine Residual(ppm)	#	#	#	#	#	#	-	-	-	-	-
As(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	6	10	-
Ba(ppb)	25	30	56	85	ND	ND	ND	ND	6	41	-
B(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	6	500	-
Cd(ppb)	ND	ND	1.7	1.9	ND	ND	ND	1.85	6	1.3	-
Cr(ppb)	ND	ND	4	13	22	27	ND	27	6	11	-
Cu(ppb)	10	10	113	62	50	28	10	113	6	45.5	39.2
Fe(ppb)	50	50	72	97	48	49	48	97	6	61	19.86
Pb(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	6	1	-

(continued)

TABLE A-7. ANALYTICAL DATA, BLUE PLAINS-SYSTEM 2 (continued)

	4 6/13/75	5 7/9/75	6 8/14/75	7 8/24/75	8 9/23/75	9 9/23/75	Low	High	n	$\bar{x}$	σ
Mn(ppb)	5	5	4.7	18.5	7	1	1	18.5	6	6.9	6.0
Hg(ppb)	0.2	0.36	0.93	1.27	0.70	0.31	0.20	1.27	6	0.63	0.42
Se(ppb)	100	ND	ND	ND	ND	ND	ND	ND	6	25	-
Ag(ppb)	0.37	0.05	0.18	1.56	1.57	0.52	0.05	1.6	6	0.71	0.68
Zn(ppb)	50	30	94	70	52	26	30	94	6	54	25
Aldrin(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	6	0.005	-
Dieldrin(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	6	0.009	-
Endrin(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	6	0.014	-
Heptachlor(ppb)	ND	ND	NL	NL	ND	ND	ND	ND	6	0.006	-
Lindane(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	6	0.004	-
DDT(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	6	0.0016	-
Chlorodane(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	6	0.017	-
Methoxychlor(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	6	0.046	-
2,4-D(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	6	0.023	-
2,4,5-TP(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	6	0.016	-
2,4,5-T(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	6	0.011	-
Diazinon(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	6	0.011	-
Ethyl Parathion(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	6	0.012	-
Imidan(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	6	0.078	-
Malathion(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	6	0.015	-
Methyl Azinphos(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	6	0.108	-
Methyl Parathion(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	6	0.018	-
Carbamates(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	6	-	-
Turbidity(NTU)	1.03	1.1	1.03	0.99	0.97	0.87	0.87	1.1	6	0.998	0.08
Odor(No.)	48.5	64	3.03	9.19	1.99	21.11	1.99	64	6	24.63	25.88
Taste(No.)	12.1	16	2.30	6.73	1.99	10.08	1.99	16	6	8.32	5.62
Suspended Solids(ppm)	ND	0.5	ND	0.5	1	1	ND	1	5	0.8	0.27
Color(Pt-Co units)	3	3	3	2	2	2	2	3	6	2.5	0.55
Temperature(°C)	#	#	#	#	#	#	-	-	-	-	-
pH	#	#	#	#	#	#	-	-	-	-	-
Conductivity(Micro mhos)	551	534	510	505	540	520	5.05	5.51	6	526.6	17.9
Foaming(Sec.)	15	10.7	20.3	70.8	30.2	101.2	10.7	101.2	6	41.4	36.5
Gross Beta(pCi/1)	<5.6	<16.4	<13.1	<22.1	<6.6	<15.0	<5.6	<22.1	-	9.9	-
Gross Alpha(pCi/1)	<1.4	<5.0	<1.3	<3.0	<2.6	<1.9	<1.3	<5	-	1.5	-
Tritium	<220	277±389	277±388	395±390	16±385	269±390	16	395	5	266.8	150.0

ND - Not detected

On-site determination; data not supplied to GSRI

TABLE A-8. ANALYTICAL DATA, ORANGE COUNTY

Parameter	1 2/11/76	2 2/10/76	3 2/17/76	4 2/20/76	5 3/8/76	6 3/12/76	n	$\bar{x}$	Low	High	σ
Total Coliform (No./100 ml)	0	0	0	0	5	5	6	2	0	5	3 .
Fecal Coliform (No./100 ml)	0	0	0	0	0	0	6	0	0	6	-
Plate Count (No./ml)	$1.25(10^5)$	$8.5(10^4)$	300	$1.2(10^3)$	15	$4.3(10^4)$	6	$4.2(10^4)$	15	$1.25(10^5)$	$5.3(10^4)$
Salmonella (D/ND)	ND	ND	ND	ND	ND	ND	6	ND	ND	ND	-
Chloride (ppm)	226.8	215.8	222.6	228.3	204.5	234.8	6	222.1	204.5	234.8	10.7
Sulfate (ppm)	340	320	310	305	270	309	6	309	270	340	23
Alkalinity (ppm $CaCO_3$)	130.5	111.0	129.0	128.3	107.8	116.4	6	120.5	107.8	130.5	10.0
$CaCO_3$ Stability (ppm $CaCO_3$)	+9.82	+7.2	+9.0	+8.2	-17.2	+7.2		4.05	+7.2	-17.2	18.8
Sodium (ppm)	4969	372	95.3	105	108	142	6	965	95.3	4969	1954
Dissolved Solids (ppm)	1122	928	970	945	820	924	6	952	820	1122	98
Nitrate (ppm) *											
Nitrite (ppm) *	ND	ND	ND	ND	ND	ND	6	0.01	ND	ND	-
Ammonia N (ppm)	18.0	16.5	13.2	12.7	12.8	15.2	6	14.7	12.7	18.0	2.2
TKN (ppm)	23.6	20.8	18.3	31.9	14.5	21.7	6	21.8	14.5	31.9	5.86
COD (ppm)	8.3	9.6	10.1	14.8	10.5	8.3	6	10.3	8.3	14.8	2.4
TOC (ppm)	5.4	5.2	5.9	8.1	8.5	5.4	6	6.4	5.2	8.5	1.5
CN (ppm)	ND	ND	ND	ND	ND	ND	6	0.005	ND	ND	-
Phenol (ppb)	ND	11.2	ND	ND	ND	14	6	7.5	ND	14	-
CCE (ppm)	0.1	0.4	0.2	0.2	§	§	4	0.2	0.1	0.4	0.1
CAE (ppm)	1.4	1.9	1.7	0.8	§	§	4	1.4	0.8	1.9	0.5
Chlorine Demand (ppm)	#	#	#	#	#	#	-	-	-	-	-
Chlorine Residual (ppm)	#	#	#	#	#	#	-	-	-	-	-
As (ppb)	ND	ND	ND	ND	ND	ND	6	10	-	-	-
Ba (ppb)	ND	ND	ND	ND	ND	ND	6	25	-	-	-
B (ppb)	ND	ND	ND	ND	ND	ND	6	50	-	-	-
Cd (ppb)	ND	ND	ND	ND	3	4	6	1.8	ND	4	-
Cr (ppb)	12	61	54	82	111	51	6	67	42	111	25
Cu (ppb)	41	46	59	53	15	25	6	40	15	59	17
F (ppm)	0.74	0.70	0.72	0.86	0.62	0.82	6	0.74	0.62	0.86	0.09
Fe (ppb)	21	15	29	38	63	46	6	35	15	63	18
Pb (ppb)	9	12	9	12	21	16	6	13	9	21	5

TABLE A-8. ANALYTICAL DATA, ORANGE COUNTY (continued)

	1 2/11/76	2 2/10/76	3 2/17/76	4 2/20/76	5 3/8/76	6 3/12/76	n	x̄	Low	High	σ
Mn(ppb)	3	3	4	4	<ND	<ND	4	2.7	ND	4	1
Hg(ppb)	<ND	0.46	0.72	1	<ND	0.40	4	0.53	ND	1	0.27
Se(ppb)	<ND	<ND	<ND	<ND	<ND	<ND	6	10	ND	ND	-
Ag(ppb)	40.5	33.7	48.9	34.2	28.1	33.0	6	36.4	28.1	48.9	7.3
Zn(ppb)	383	145	212	910	47	1234	6	488	47	1234	476
Aldrin(ppb)	ND	ND	ND	ND	ND	ND	6	0.005	ND	ND	-
Dieldrin(ppb)	ND	ND	ND	ND	ND	ND	6	0.009	ND	ND	-
Endrin(ppb)	ND	ND	ND	ND	ND	ND	6	0.014	ND	ND	-
Heptachlor(ppb)	ND	ND	ND	ND	ND	ND	6	0.006	ND	ND	-
Lindane(ppb)	ND	ND	ND	ND	ND	ND	6	0.004	ND	ND	-
DDT(ppb)	ND	ND	ND	ND	ND	ND	6	0.0016	ND	ND	-
Chlorodane(ppb)	ND	ND	ND	ND	ND	ND	6	0.012	ND	ND	-
Methoxychlor(ppb)	ND	ND	ND	ND	ND	ND	6	0.046	ND	ND	-
2,4-D(ppb)	ND	ND	ND	ND	ND	ND	6	0.023	ND	ND	-
2,4,5-TP(ppb)	ND	ND	ND	ND	ND	ND	6	0.016	ND	ND	-
2,4,5-T(ppb)	ND	ND	ND	ND	ND	ND	6	0.011	ND	ND	-
Diazinon(ppb)	ND	ND	ND	ND	ND	ND	6	0.011	ND	ND	-
Ethyl Parathion(ppb)	ND	ND	ND	ND	ND	ND	6	0.012	ND	ND	-
Imidan(ppb)	ND	ND	ND	ND	ND	ND	6	0.078	ND	ND	-
Malathion(ppb)	ND	ND	ND	ND	ND	ND	6	0.015	ND	ND	-
Methyl Azinphos(ppb)	ND	ND	ND	ND	ND	ND	6	0.108	ND	ND	-
Methyl Parathion(ppb)	ND	ND	ND	ND	ND	ND	6	0.018	ND	ND	-
Carbamates(ppb)	ND	ND	ND	ND	ND	ND	6	-	ND	ND	-
Turbidity (NTU)	0.97	1.05	0.97	1.0	1.3	1.04	6	1.06	0.97	1.05	0.13
Odor(No)	6.96	12.13	9.19	4.5	8.0	12.1	6	8.83	4.49	12.13	2.96
Taste(No.)	§	§	§	§	§	§	-	-	-	-	-
Suspended Solids(ppm)	3.0	2.0	4.0	4.0	3.0	ND	6	2.7	ND	6	1.5
Temperature(°C)	#	#	#	#	#	#	-	-	-	-	-
pH	#	#	#	#	6.69	#	-	-	-	-	-
Conductivity(Micro mhos)	1887	1734	1800	1800	1600	1800	6	1770	1600	1887	96.5
Foaming(Sec.)	5.8	30.0	7.2	10.0	6.5	24.0	6	13.9	5.8	24.0	10.4
Gross Beta(pCi/1)	<13.4	<10.9	<12.0	<12.0	<19.0	<21.0	6	14.7	10.9	21.0	
Gross Alpha(pCi/1)	<2.4	<6.8	<3.7	<6.3	<2.4	<7.4	6	4.8	2.4	7.4	
Tritium(pCi/1)	980±510	440±280	390±380	890±410	750±395	1550±420	6	833	390	1550	423

(continued)

§ Data not available

On-site determination; data not supplied to GSRI

TABLE A-9. ANALYTICAL DATA, ESCONDIDO

Parameter	1 7/8/75	Parameter	1 7/8/75
Total Coliform (No/100 ml)	0	Chlorine Residual (ppm)	#
Fecal Coliform (No/100 ml)	0	CN (ppb)	0.06
Total Plate Count (No/ml)	700	Phenols (ppb)	7.4
Salmonella (D/ND)	ND	Aldrin (ppb)	ND
Chloride (ppm)	24.3	Dieldrin (ppb)	ND
Sulfate (ppm)	1.6	Endrin (ppb)	ND
Alkalinity (ppm $CaCO_3$)	6.1	Heptachlor (ppb)	ND
$CaCO_3$ Stability (ppm $CaCO_3$)	+97.7	Lindane (ppb)	ND
Sodium (ppm)	27.0	DDT (ppb)	ND
Dissolved Solids (ppm)	82	Chlorodane (ppb)	ND
Nitrate (ppm)	9.0	Methoxychlor (ppb)	ND
Nitrite (ppm)	ND	2,4-D (ppb)	ND
Ammonia N (ppm)	0.967	2,4,5-TP (ppb)	ND
TKN (ppm)	1.83	2,4,5-T (ppb)	ND
As (ppb)	ND	Diazinon (ppb)	ND
Ba (ppb)	ND	Ethyl Parathion (ppb)	ND
B (ppb)	ND	Imidan (ppb)	ND
Cd (ppb)	ND	Malathion (ppb)	ND
Cr (ppb)	ND	Methyl Azinphos (ppb)	ND
Cu (ppb)	10	Methyl Parathion (ppb)	ND
F (ppm)	0.262	Carbamates (ppb)	ND
Fe (ppb)	20	Turbidity (ppm SiO_2)	0.83
Pb (ppb)	ND	Odor (No.)	13.9
Mn (ppb)	ND	Taste (No.)	3.5
Hg (ppb)	0.26	Color (Pt-Co units)	ND
Se (ppb)	180	Suspended Solids (ppm)	ND
Ag (ppb)	0.23	Temperature (°C)	#
Zn (ppb)	30	pH	#
COD (ppm)	1.9	Conductivity (Micro mhos)	156.1
TOC (ppm)	6.9	Foaming (sec.)	2160
CCE (ppm)	§	Gross β (pCi/1)	<3.9
CAE (ppm)	§	Gross α (pCi/1)	<0.4
Chlorine Demand (ppm)	#	Tritium (pCi/1)	116 ± 213

ND-Not detected

§ Data not available

On-site determination; data not supplied to GSRI